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AQA – GCSE Design & Technology
Specification – 8552
Summer 2019

GCSE Design & Technology

Analysis of the task

The Task

I have chosen to address the contextual challenge of encouraging a healthy lifestyle. For each challenge, I came up with a draft mind map to assess the problems that fell within them, this helped me find the challenges which were more suitable to me. When analysing the task of encouraging a healthy lifestyle I found a wider variety of tasks that I would be able to design a product for and tasks I had more interest in. There are several aspects to living a healthy lifestyle which came up in my research. Simple things like eating a healthy diet and exercise. To more complex topics such as sleep deprivation which has been said to lead to problems such as obesity and heart disease.

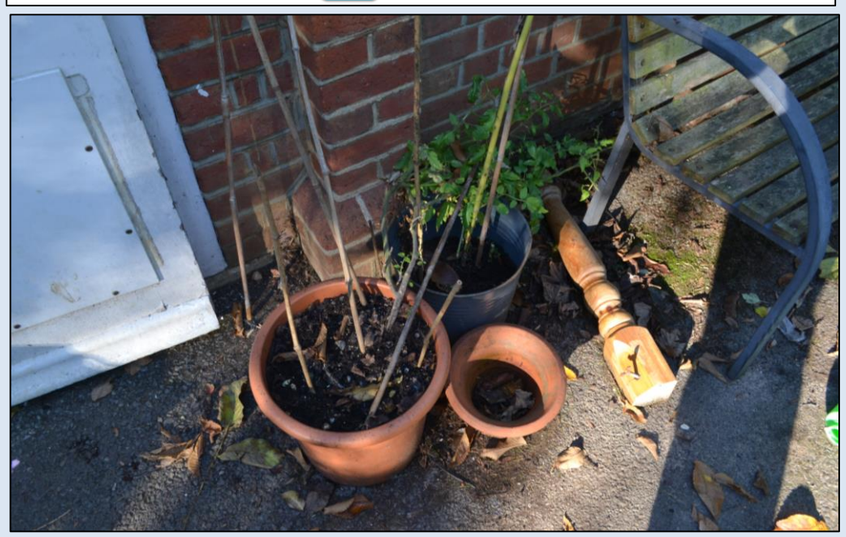
Mind Map

From this mind-map, I have been able to get a good understanding of the opportunities that could come out of encouraging a healthy lifestyle. I split the context into five topics which I used to highlight some opportunities that would be ideal for my NEA. I tried to come up with topics which I had a broad understanding of. My mind-map also has a common theme of electronics as this is a topic I am experienced in and I feel it would be appropriate to try and produce something that incorporates this. While doing the mind-map, I felt that the topic of growing your own was a good topic to look into as I immediately had some initial ideas on how this problem could be tackled.

From these ideas, I went on to find a suitable client that I felt would benefit from my product.

Early Thoughts

After looking online at some ideas on what my product could offer I have found some features that I might be able to implement. Hydroponics is the process of growing plants without soil. This type of farming can use up to 95% less water. It is a whole branch of agriculture which has recently been adopted by some companies because it is more sustainable and cheaper to maintain. Another idea I was interested in was high density farming, with plants growing vertically and upside down. This is not only more efficient but would also give the product a more aesthetically pleasing design. Another subject I will need to look into during my context research is what conditions are the most suitable for the type of plants I will be growing.

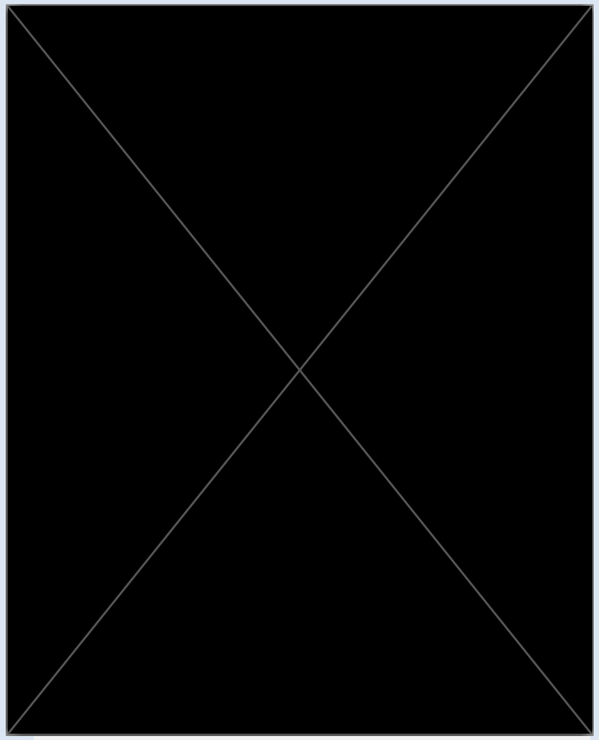


The Problem

Upon showing the client the ideas that I had related to the context, they said that a product which allowed them to grow their herbs and vegetables inside the home would be extremely useful. They said that they had attempted to start growing their own however it brought several problems which outweighed the benefits. They mentioned that they had a problem with insects eating the leaves off their vegetables and that due to time constraints they weren't able to water it enough and it added more worry than it did enjoyment. They like the idea of being able to monitor their plants over time by an app and said that this would be extremely useful as before it was very hard to tell whether they were growing well.

Pictured to the left are a few of the clients several plant pots which due to time constraints are often sadly left empty.

Client's Needs and Wants



The client is a keen cook and especially enjoys using ingredients grown by herself. Unfortunately due to her busy lifestyle she is often unable to keep up with this hobby. The client is also physically active and enjoys living a healthy lifestyle by having a balanced diet. I have chosen them as my client as I feel they are most suitable for my context area.

Discussion Topics

During my meeting with the client to gather their requirements, I discussed the main points which I felt were important for the development of my product.

Home Style

The client said that she preferred a uncluttered home so anything that would add more hassle than convenience would not be ideal. Her kitchen is a particular area which she likes to keep clear and as this is one of the prospective locations for the product.

Location

The client proposed the following locations where the product could be located:

- Back Garden
- Hallway
- Kitchen
- Bathroom

The client said it would be most convenient if the herbs were easy to access when needed which in this case the ideal location would be the kitchen.

Colours

The client said they preferred more muted colours (greys, muted blues, greens and cream) compared to outgoing vibrant colours (red, yellow, purple) and would prefer if these did not feature in the design if it was to be on display in her home.

Requirements

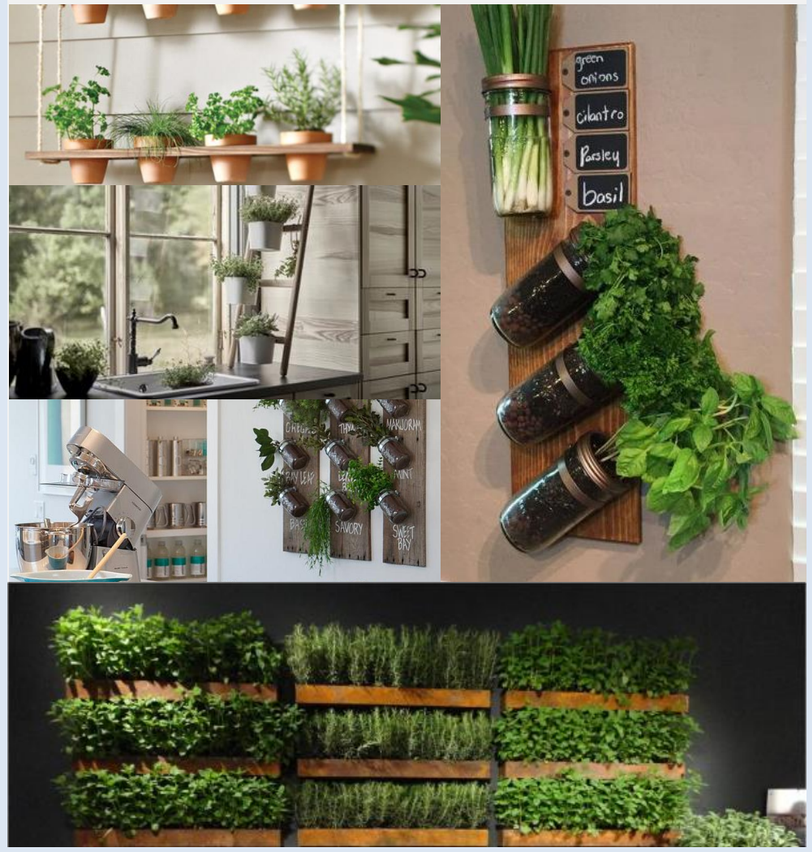
The client said needs to be able to cultivate several different types of herb and allow for quick and easy changing which shouldn't need any second thought.

Conclusion

After speaking to the client, I have been able to gather a better picture of what sort of product she would desire and how I should approach my design. A key point I have gathered is that simplicity is important for my client.

Ideas drawn from interview

My client and I looked on the internet at previous products that would suit her style. Through this research I was able to gather that my client likes natural materials such as wood and glass. I also found that she has a simplistic style which I should try and convey in my final product.



Work of Others – Strengths and Weaknesses

The product is made of wood which looks aesthetically pleasing to the target market as well as being durable. This means it can be placed almost anywhere as pictured above. There are several different ways the product can be mounted to make it more flexible for the customer.
The product is less practical than other alternatives as it does not use space as efficiently as others. This is because it is designed to be a garden attraction instead of just being a herb garden. The product discolours after a while in the outdoors due to the garden conditions.

After looking at the strengths and weaknesses of this product I have concluded:

- If I was to make a product out of wood, I would need to make sure that I finish it with sufficient waterproofing.
- Customers prefer if the product is more attractive than practical in some cases.
- If my product was to go outside it would need to have sufficient protection to last a long time.

The product is made out of grey stainless steel to give it a neutral tone. This means it fits into the home better and is less noticeable. The product comes with an LED light so it does not have to be placed in direct sunlight giving flexibility to the customer. The plants are grown using hydroponics which is more sustainable for the future.
Once one plant manages to grow big enough to cover the LED light, the others do not get any light. The product is not able to be placed outdoors. The product is quite expensive for what it is.

After looking at the strengths and weaknesses of this product I have concluded:

- Neutral colours work better in the home and if my product was to be indoors I should use similar neutral tones.
- I should try and add as much flexibility to the product as possible by including features such as LED lighting.
- My product does not have to be too complicated to be effective.

The product is very simple to use. It does not need any batteries and lasts a long time. It is much cheaper than other electronic alternatives. The product can be used for any plant big or small. It is spiked to make it easier to place in the ground.
The manufacturer has made the product green to try and blend it in with the plants leaves however I feel this is somewhat ineffective. It is quite a obnoxious design and some customers might not like the fact that it is one of the main features of the plant.

After looking at the strengths and weaknesses of this product I have concluded:

- Customers often value simplicity.
- I want my product to supplement the plant not be the main feature.
- The shape of my product should be carefully considered for the products purpose if I am going to design a similar device.

Conclusion

From looking at the strengths and weaknesses of other products, I have been able to come up with an idea on what works well in my product range and what doesn't. While researching the various products that were in my field I also came up with some ideas in how I could implement their features into my product. As my client has said it would be more preferable if the product was in their kitchen, I will follow the suite of other manufacturers by using neutral tones and more complex features such as LED lighting to allow my product to be as practical and functional yet aesthetically pleasing as possible.

Work of Others – Product Analysis

The product is a self contained ecosystem which replicates real life habitats. Allowing the owner to keep tropical plants and pets. There are several different sizes and configurations to meet the owners needs. With the use of electronics, the product is able to be viewed remotely on a device which is convenient for the owner when they are away.

It is simplistic in style and designed to fit into several different kinds of spaces. It comes in various different form factors to allow it to fit into several different kinds of gaps in the home. The top in the plant models is open with a light over the top which means it can be placed out of sunlight. Most of the models are quite large and often quite noticeable.

Primary Customer Feedback

I own three Terra units and I've spent more time fixing them than growing anything inside of them. The amount of water you have to keep in the bottom of the tank at all times for the irrigation to work makes everything turn into a swamp and crashes any bioactive environment you're trying to get going. While the company was very responsive at first, I'm now on my third printed circuit board for one of my units, and though I emailed and called twice three weeks ago, I have yet to hear anything back from them.

From this review and others which follow a similar theme, I have gathered that the product is flawed in several areas. The product definitely has some defects which cause units to fail. One of the main problems I gather from looking through the reviews is that the water from the pump which helps keep the humidity stable for the tropical conditions, because it is in close proximity to the electronics, sometimes leaks and causes the unit to fail. Even though I will not be using a pump for humidity I will need to make sure that the water supply system and the electronics are kept sufficiently apart.

The product is a indoor herb garden which allows you to grow your herbs indoors. Fresh herbs are very easy to access with this product and a chalk board is provided to add a personalised touch. It is stylish and complements the décor of any kitchen and fits well on a windowsill for natural light. It is also versatile, it can be used for plants such as cacti as well to add a tropical vibe to the space.

Primary Customer Feedback

Bought this to repot herbs bought in the supermarket, so I cannot comment on the quality of the seeds. Very happy overall as my kitchen window sill looks a lot tidier now. I was very pleased to see that the pots have a hole at the bottom so excess water can drain and there is a very discreet plastic tray to protect the wood from water. So pleased I'll probably get a second one down the line and have more herbs to choose from! :)

If you like the shabby chic, cottage type look, this is for you. I have bought one for myself, and subsequently one for my daughter. You can fill with already established herb pots, or use the seeds enclosed. I have done both, and both work nicely. Being able to write in chalk, what the contents are is a very nice classy touch

From these reviews, I can tell the product is popular. The rustic style which the customers of the product described has also come up in other products I looked into during my analysis. This might be a good theme to try and get into my product when I come up with some initial model ideas. I also like the idea of adding some form of personalisation like the chalkboard the manufacturer provided. I feel this would add a more personal to the product and make it fit better into a home environment.

Impact on society, economic and social effects

My product would have a positive effect on society as it would be encouraging a healthy lifestyle as a whole. Specifically, it would persuade more people to grow their own and in turn consume more healthy food. The product would bring economic value to the home as it would allow the consumer to cook food cheaper and more effectively. The social effects would also be positive as the product would be a visual indicator of a healthy lifestyle, encouraging people who view it to give it a go themselves. I will need to make sure that the product is accessible to minorities such as the disabled and ensure that I carefully think about what some colours/materials may symbolize in different cultures (e.g. China has a wide variety of meanings behind specific colours).

Context Specific Research

Location of Product

After consulting with the client, they said that the product would be most suitable in their kitchen as it would be easy to access for the herbs and they would also be able to check up on it as it is a space they are frequently in.

I gathered the dimensions for the space which the client said it could take up, they were: **66mmx500mmx430mm**

This is quite a large space which means I can be flexible with my design and I do not have to conform to any space restrictions. The space is next to two electricity sockets which means that If I was to incorporate electronics, it would be easy to connect. The space consists of neutral colours so my product would not be suitable if it stood out. At the moment, there are no other plants growing in the kitchen.

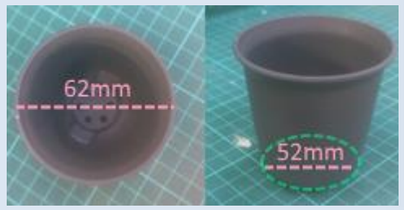
Client's Kitchen – 66mmx500mmx430mm

Types of Pot

For my product I needed to look into the different types of pots that I would be able to use. I gathered several different sizes and types of pot. As my client has requested the product is designed for herbs specifically I thought it would be more appropriate to have smaller pots. I also needed to check that the pots had sufficient drainage (holes in the bottom) to allow the roots to "breath" after being watered. This will also mean that in my final product I will need to make sure there is a sufficient drainage system to get rid of the excess water. After testing a variety of pots I chose pot B due to it's simplicity and neutral tone which matched my specification.

A

B



Lighting

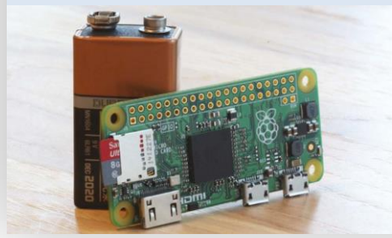
Plants require light to grow properly, although the kitchen already has natural light coming through the window. I thought it would be a good idea to give the product it's own dedicated light to make sure that it is growing at its maximum rate. Upon further research I found some "grow lights" which advertise that they offer a perfect light for plants to grow effectively. However they have quite a distinctive bright purple colour which would be against my clients wishes of the product being of a more neutral tone. Upon looking further, I found some lights which offered a similar feature but had a more traditional cool white glow.

Plant

I would like my product to be as flexible as possible and cater for a wide range of different species of plant. In my initial research I came across the topic of hydroponics. Upon further investigation I do not feel this would cater for my clients requirements as it needs to be simple to use and ordering specialist nutrient solutions instead of just simple soil which can be found in any garden centre. So I will be going with standard soil plants. This means my product will be able to grow any herbs that can grow at room temperature. Another item that popped up in my research is the time that a plant should be in light. Over millions of years plants have evolved to our daylight cycle so my artificial lighting would need to follow a similar pattern. This could be achieved through the use of a micro controller.

Microcontrollers / Computers

After researching microcontrollers and computers which are suitable for electronics projects like these I came across two options: Raspberry Pi and Arduino. There are two key difference between them. The raspberry pi is a complete computer package with software already installed that allows it to perform complex operations such as connecting to the internet and storing data. It is also incredibly small. The Arduino is a simple microcontroller which can be programmed to perform simple functions like turning switches on and off. For my project, I feel the Raspberry Pi would be more suitable.



Developing Clients Interests

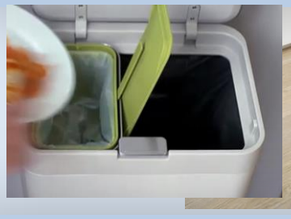
Analysis of Client's Brand Interests

After my analysis of products within the field of home growing, I decided to discuss with the client further around what kinds of products she likes. As my client said her preferred location would be the home kitchen I thought it would be a good idea to look into the kind of brand styles she likes. I asked my client what her favourite brand was and she responded with the houseware and design-led brand Joseph Joseph.

I was pleased with her choice of brand as we had discussed some of the Joseph Joseph products in class and they are an excellent example of good product design. The products feature a modern look with smoothed edges. Most of their products are injection moulded which I am not able to do in school but I should be able to replicate similar features.

I asked the client what her favourite product was from the brand and she said that her "intelligent waste bin". The product has separate compartments for different kinds of waste such as compost. I decided to analyse the product to look at the design features.

Removable Compost Bin
There is a removable compost bin which the allows the client to move it around their kitchen for when they are cooking so they don't have to constantly walk backwards and forwards.



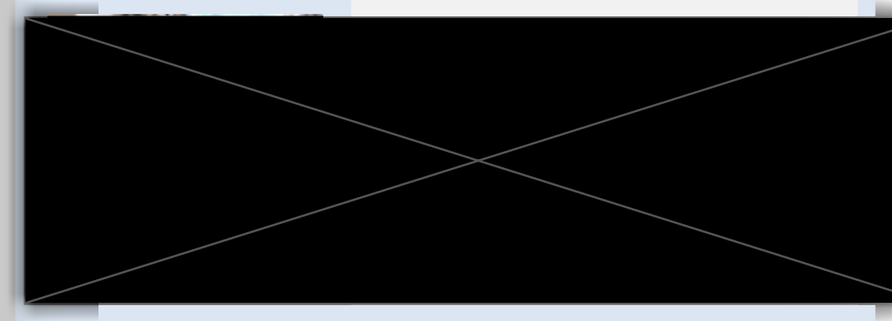
Removable drawer
The bottom of the product is a removable drawer which allows any other type of waste such as newspapers, bottles etc.. to be hidden away.

Overview of Product
The products design is unique which makes it stand out among others. It is not any ordinary bin, careful consideration has gone on behind the scenes to create a product which is truly useful. Innovative features like the removable drawers make this product stand apart from the crowd.

Colour

I asked the client if she liked the colours of the Joseph and Joseph products as my current specification was quite vague. She responded positively saying she would "love it if the product matched the Joseph Joseph colours" as it would match the rest of her kitchen style. I will try my best to incorporate these as my main colours.

Interview with Gardening Expert



What would you expect in a home gardening product?

In a home gardening product. I would expect it to be extremely durable as it will have to undergo a lot of strain from constantly being watered and moved around. All surfaces should definitely be waterproof and it should be stable to ensure it does not fall over and get soil everywhere! I also think that it is important that the product does not appear too industrial otherwise it will most likely be put in a back cupboard and forgotten about.

Do you feel there is a market for indoor gardening products?

I definitely feel there is a market for these kinds of products. Currently, the market is fairly bland with products which all seem to copy each other. It would be great if the product had a defining feature which set it apart.

What features would you like to see in a product like this?

Automatic irrigation like you have mentioned would be great as technology which perform actions for us in the home is becoming more and more mainstream so this would be super and I am sure that most others would love it as well.

Conclusion

[redacted] I have gained a valuable insight into the gardening world and gathered some important feedback which I should incorporate into my specification to ensure I am making a quality product.

Design Specification

Design Brief

My product is a indoor herb garden which will allow it's user to grow herbs around the home. It will be designed to be as intuitive as possible with as little user intervention needed as possible. It will utilise technologies such as LED lighting to allow its placement to be as flexible as possible. It will follow a minimalist style as this is what the client requested during my discussions with her. The product should also be relatively small to allow the user to be flexible in it's placement. The product will help encourage a healthy lifestyle by encouraging the user to grow their own. The product should allow the user to quickly switch out their pots while in use and be made of a durable material to sustain the strain it will have to undertake.

How my product should look

- The product's colour palette should match the client's kitchen. The client's kitchen has mainly monotone colours so it would be more suitable to have colours that follow this theme. The client has said that any colours which follow the theme of a plant (e.g. brown/green) are acceptable as well.
- Any joints that join two materials together should be unnoticeable or hidden away to make the product appear more aesthetically pleasing to the user.
- Any piping/cabling for the product's lighting and water should be hidden from view to make the product appear more aesthetically pleasing and to make the product fit in the client's kitchen.

Dimensions relating to the product

- The whole product should fit in the space the client has provided of 66mmx500mmx430mm. It should use the space as efficiently as possible to allow the client to grow as many herbs as possible.
- Any holes that will contain the pots need to be 58mm in diameter to allow the pots to fit snugly. The pot size for the product must be 65mm x 65mm with an outer diameter at the top of 64mm. From my research, I have found that by investigating several pot sizes, this is the ideal size for growing herbs.
- After speaking to the client, I have understood that the suitable number of pots for her herbs would be 6. This will allow the client to grow a variety of herbs. This amount of pots also means that the pots would fit in the dimensions given by the client.
- The plants should be able to grow with sufficient space. From my research, I have been able to gather that the average herb requires at least 70mm radius laterally and 100mm of space upwards to grow effectively.
- The product must be able to stand itself upright. I will have to make sure that the product is not top heavy during construction which could lead to the plant pots becoming damaged if the product is unstable.

How my product will work

- The product will be fitted with a lighting system to allow the plants to grow out of the presence of sunlight. The client said this would be extremely useful as natural light in her kitchen is hard to find.
- The product will run off a low voltage USB power supply. This will mean the product is convenient to set up as most people have several USB charging points around the home
- The product will be fitted with a roof for aesthetics purposes and to protect the plants from the elements when outside.
- The product must be able to support the plant pots for a long period of time.
- The product will be fitted with a pump connected to a tank to allow the user to quickly water the plant pots.

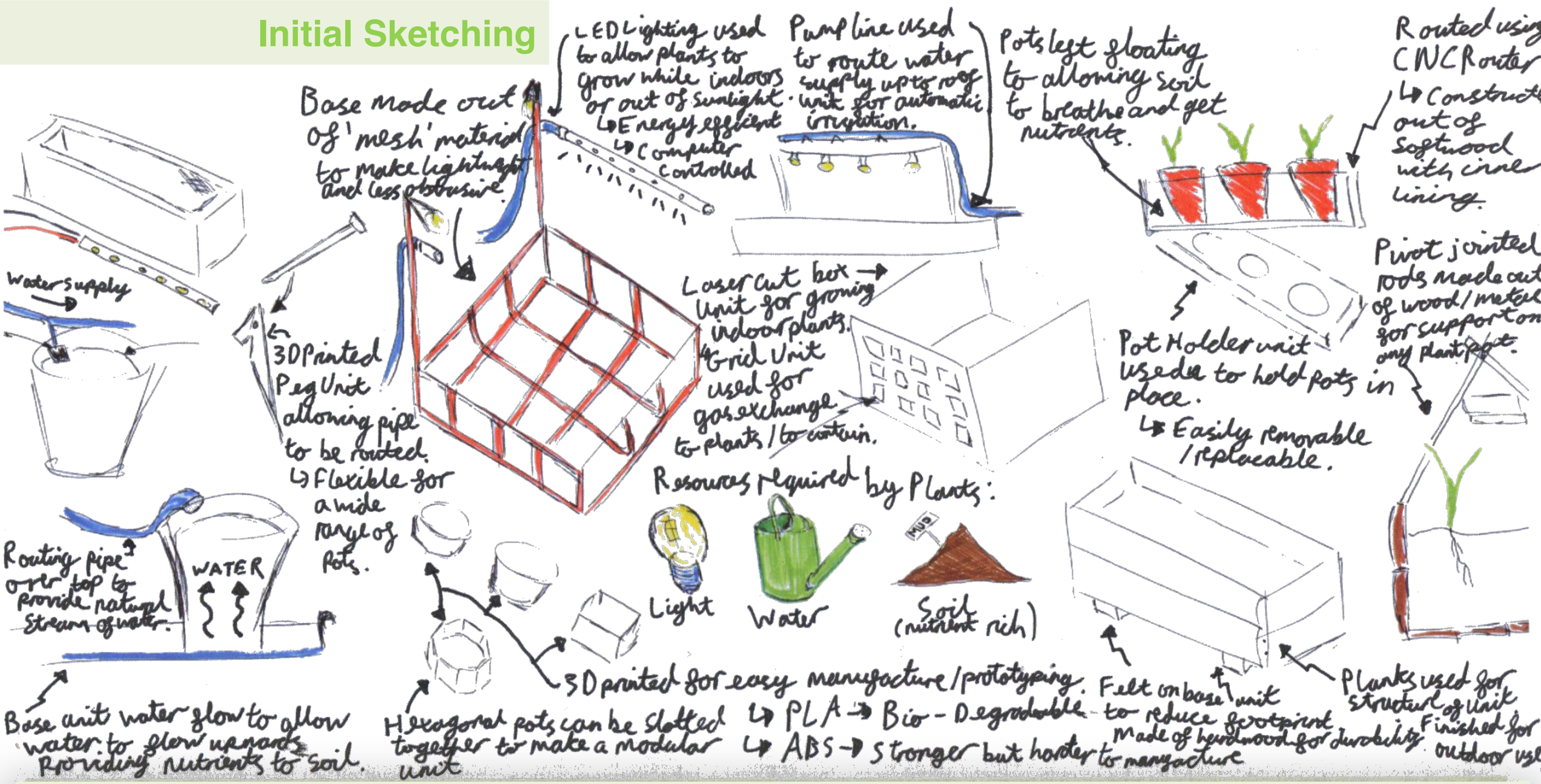
Usage

- The water tank connected to the pump mechanism must be easy to refill. It should not need any prior knowledge to operate.
- Any electronics used in the product should be low voltage and carefully routed to avoid any contact with water from the pump system.
- All piping should be adequately sealed to avoid any leakage.
- Any surfaces that could come into contact with soil and water should be adequately waterproof so the products colour will not degrade over time. This is also important for when the product may be placed outside
- The user should be able to switch out plant pots with ease and limited hassle.
- The product should have some form of labelling system so the user can know what each pot is growing.
- The product should be flexible in where it can be placed and should therefore not conform to any style to suit one particular location.

What my product will be made of

- The product will be made of materials which the client has approved. This includes a form of hardwood for the base, two aluminium rods for support and a styled plastic roof.
- All my materials should be sustainably sourced so if the product was to be mass produced there would be no supply issue.
- The products material cost should be under £15, from my context research I have found that the average material cost for a similar product is around this range.
- All surfaces should be made of some form of waterproof material or finished. This will allow the product to be used outdoors and also protect against the daily wear and tear the product will have to undergo.

Initial Sketching



What I have learned from these sketches

From these sketches I have been able to gather a wide range of different ideas on several design concepts which could be incorporated into my product. I drew out some different pot shapes which I will continue to develop on the following slides. I also had a look into the different mechanisms that could be utilised to transport the water from the pump to the actual pots. Designs included: clip on pegs which could route piping to any pot, a base unit with a constant water flow and a roof irrigation unit. I will continue developing these ideas in my Generating Ideas Section. My next steps are to draw out some more detailed design ideas and gain a better understanding of my product could come together. After showing the client these ideas, she felt the concepts were strong however it was quite an early stage to get feedback so I went on to draw the more detailed design ideas.

Generating Design Ideas

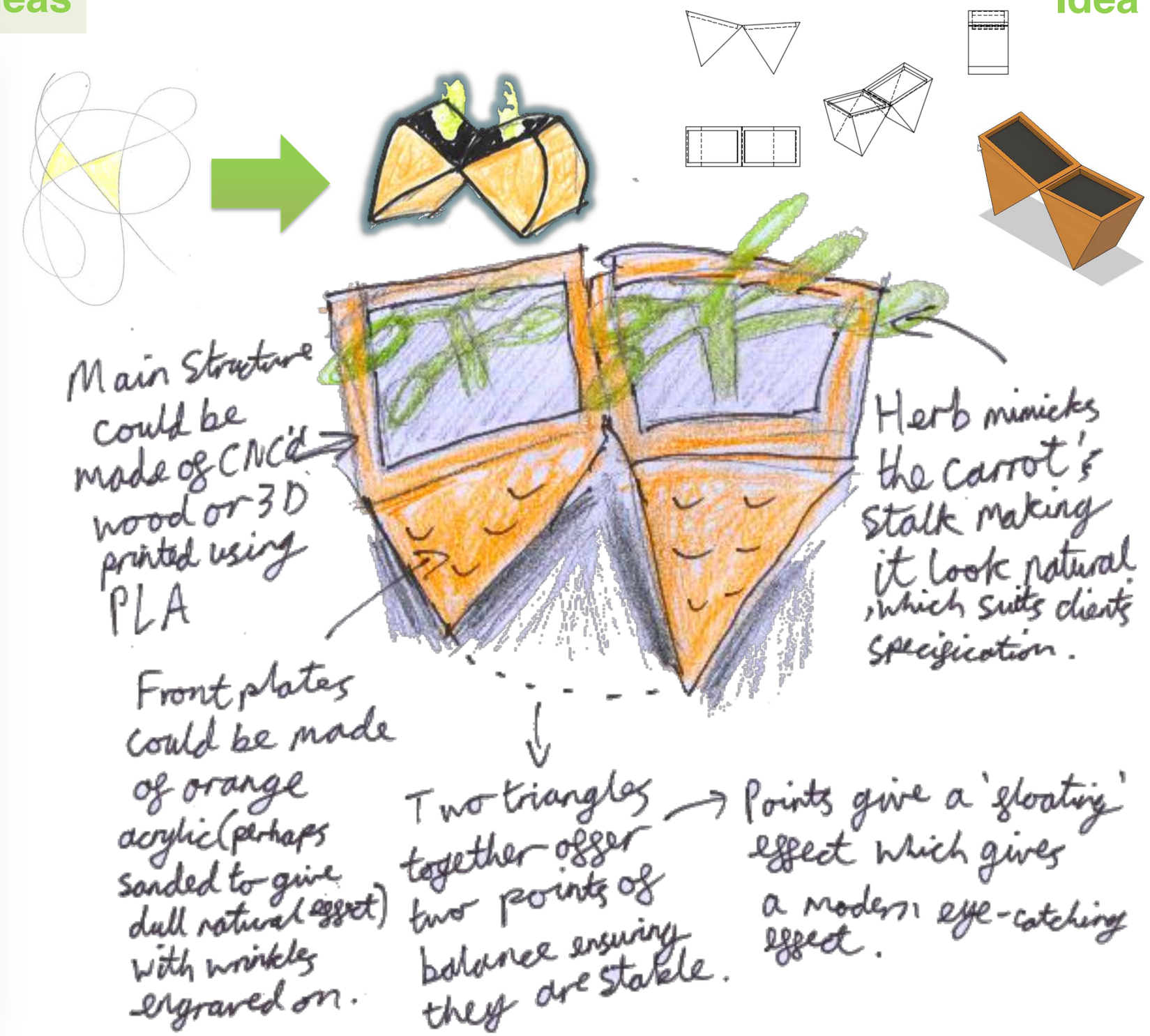
Idea 1

Overview
I came up with design by using the “doodle technique”. When I first saw the shape I imagined the image of two carrots, and the plants acting as the stalks.

Advantages
- Fits the client’s given criteria
- Fairly easy to produce
- Unique and imaginative, different to several other products on the market

Disadvantages
- No kind of way of automatically watering the plants or making it any easier for the client.
- Fairly dull in terms of shapes, just two triangles.
- The orange colour would stand out in the client’s kitchen, something she specifically did not want.

Client’s Thoughts
After showing the client idea, she liked the idea of the product resembling something natural but described it as being a bit “gimmicky”.



Generating Design Ideas

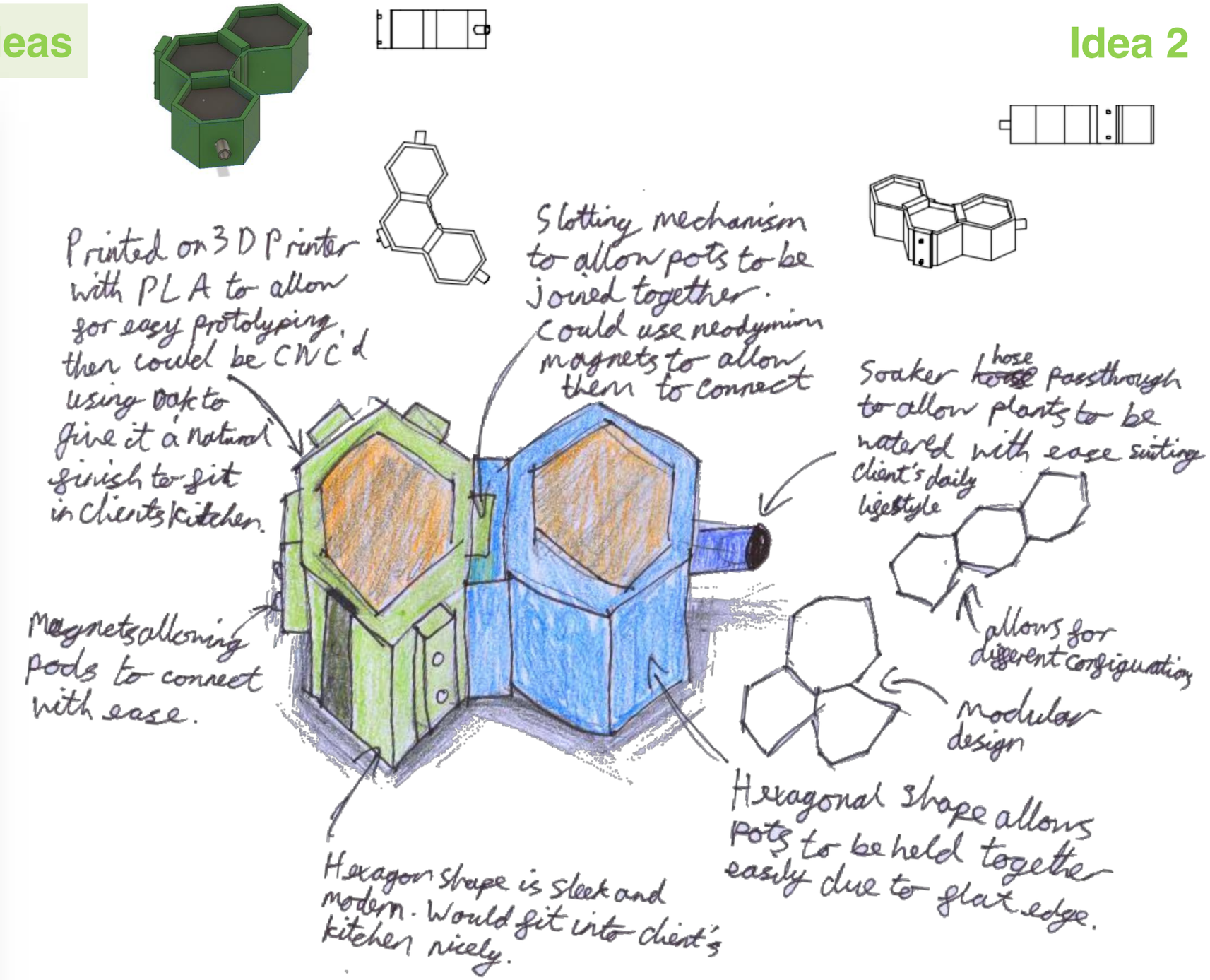
Idea 2

Overview
After the client saying she liked the idea of the product resembling something natural. I tried brainstorming some other ideas which were based off nature. In this design, I based it off honeycomb with hexagonal modules which would join together allowing the user to customize their configuration.

Advantages
- Fits the client's given criteria
- Customizable by the client. Slots together easily.

Disadvantages
- Quite "modern" which might not fit the client's specification criteria.

Client's Thoughts
The client again liked that the product was based off honeycomb but did not feel it would really suit her current kitchen environment. She also said that the hexagonal pots although they look aesthetically pleasing might not be very practical.



Generating Design Ideas

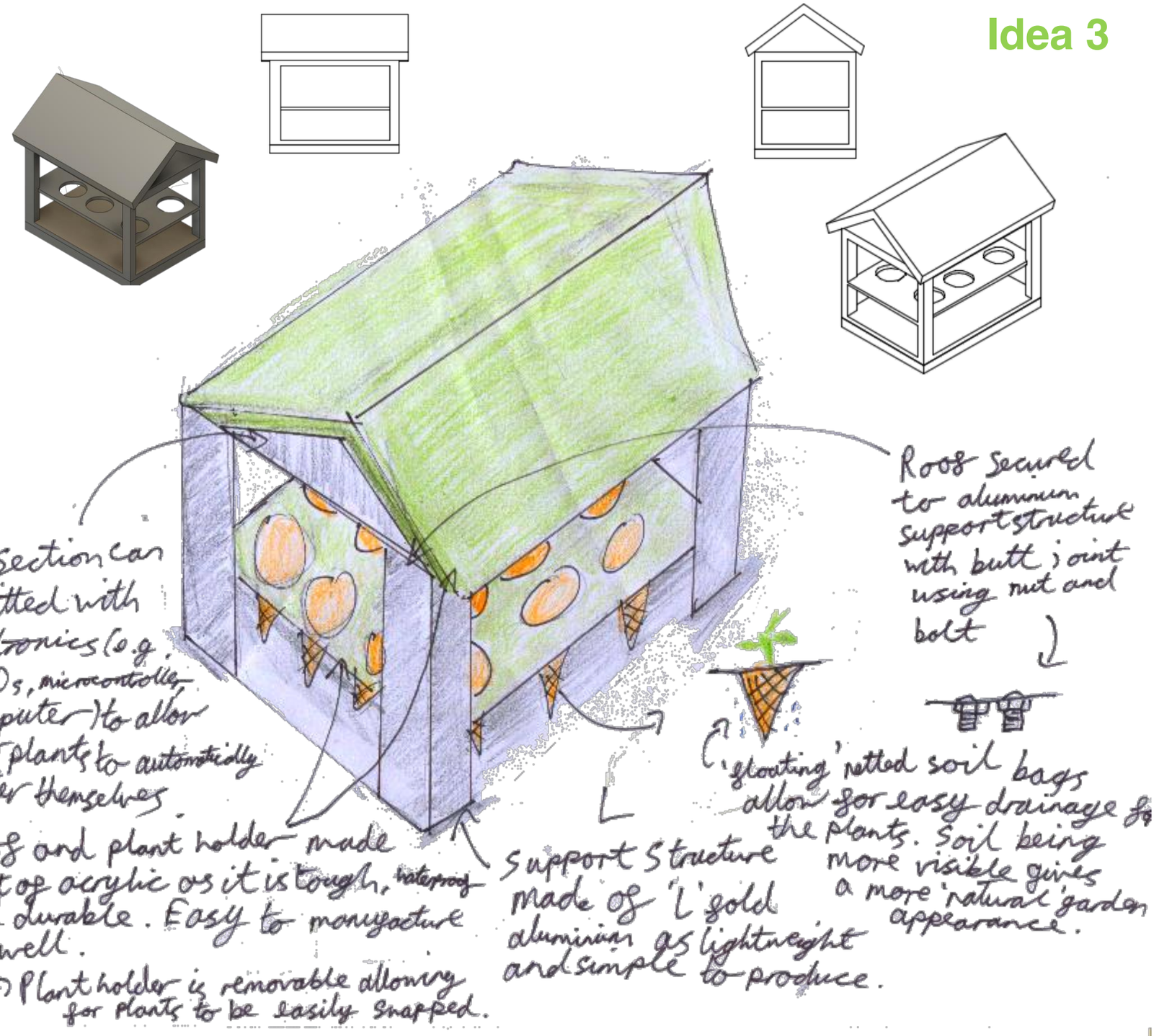
Idea 3

Overview
Continuing the theme of using nature to influence my designs. I attempted to base this concept off the common garden shed/greenhouse. These objects are often associated with growing so it gives a visual prompt to the user that it is for growing plants.

Advantages
- Fits the client's given criteria
- Distinctively has the pointed roof shape that a shed/greenhouse would have.

Disadvantages
- Although inspired by nature, the design is quite "clunky" and a shed is often built for purpose not for aesthetic purposes so the design may not suit the client's kitchen.

Client's Thoughts
The client liked the idea however they immediately felt that it was quite large and they were slightly concerned about where it would fit. They suggested that perhaps a similar model could be designed but with a longer length.



Generating Design Ideas

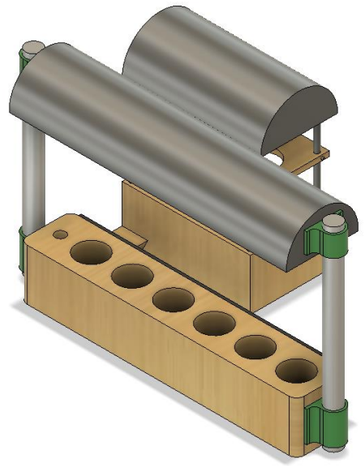
Idea 4

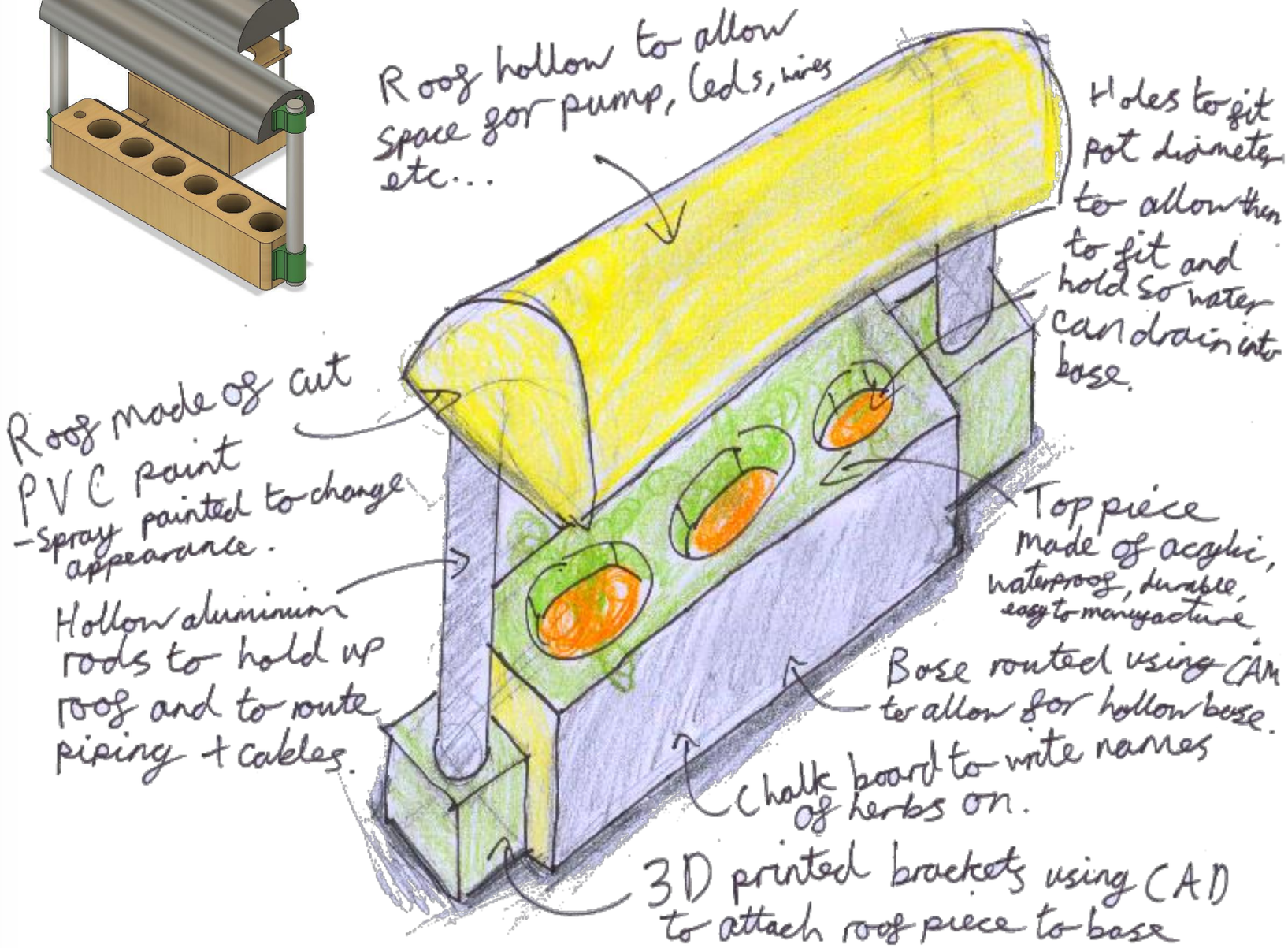
Overview
This design is inspired by all the previous comments from the client. I tried to make it as simplistic as possible but practical. The product now has a longer footprint ideal for somewhere like a window shelf.

Advantages
- Fits the client's given criteria
- Rounded roof giving the product a more aesthetically pleasing look.
- The footprint of the product is small and the plants are shown well due to the large amount of space allowing them to grow.

Disadvantages
- This design does not really have any inspiration from nature.
- The product may have stability issues due to its narrow footprint, this will need to be checked in testing.
- Not much space for electronics to be mounted, may increase manufacturing time in mas production.

Client's Thoughts
The client felt this was the best idea so far. The footprint of the product was perfect for where they wanted it to be placed (a windowsill) and they especially liked the idea of it being simplistic as this would suit her kitchen. However they felt the yellow colour was obnoxious and did not feel it would suit the kitchen and advised that it should be something of a lighter tone.





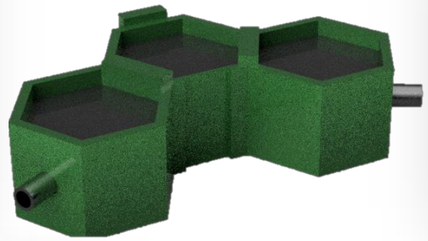
Developing Design Ideas

Client's Thoughts
The client liked the idea of the design idea. She thought the idea of the hexagonal pods connecting together was intuitive and particularly liked the idea of their being a wide range of customizability. However she questioned whether the product would suit the environment of her kitchen.

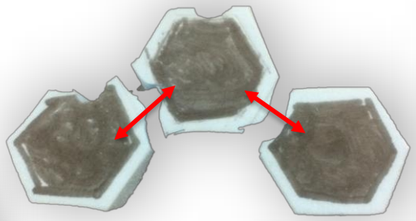
Design 1

Overview of the Design
After drawing up my initial ideas, I decided to develop the idea of being able to have a modular pot system which would allow the consumer to vary the configuration of their pots to make the design suit their home. I chose to use a hexagonal shaped pot as it was the most flexible to work with for exploring different concepts for the design. The hexagon shape also looks aesthetically sleek and modern to fit in to my client's requirements. The hexagonal shape also means plants can be placed together closely making the best usage of space making the product ideal for small kitchens.

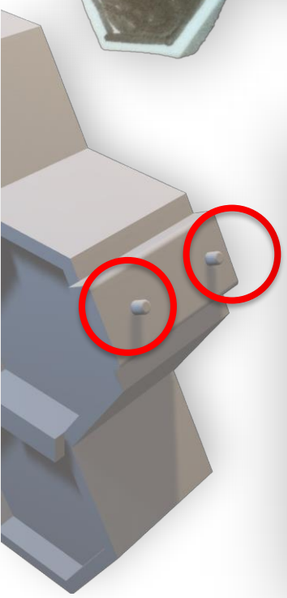
I started development of the hexagon pots idea by making a 3D foam model so I could get a better idea of the space usage of the product. This model was 18cm by 9cm by 50cm which fitted within the client's requirements. The hexagonal shape gave the product a modern futuristic look.
The product could hold the herbs sufficiently and provided enough space for the plants to be easily watered without much effort.



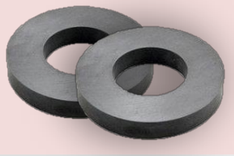
I continued development of this design idea by creating a 3D CAD model so I could display my idea to the client more clearly. After my research into the ideal pot volume I went with the hexagonal volume of 50cm^3. I elongated the slot divider to separate the pots clearly and allow the user to easily separate the units.

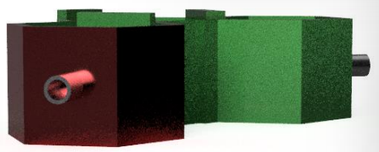


However, the design was quite "clunky" and hard to move around. Which made me consider the possibility having a modular slotting system which would allow the consumer to display their plants in several configurations. The system is also much more flexible as it allows the dimensions of the product to be modified.

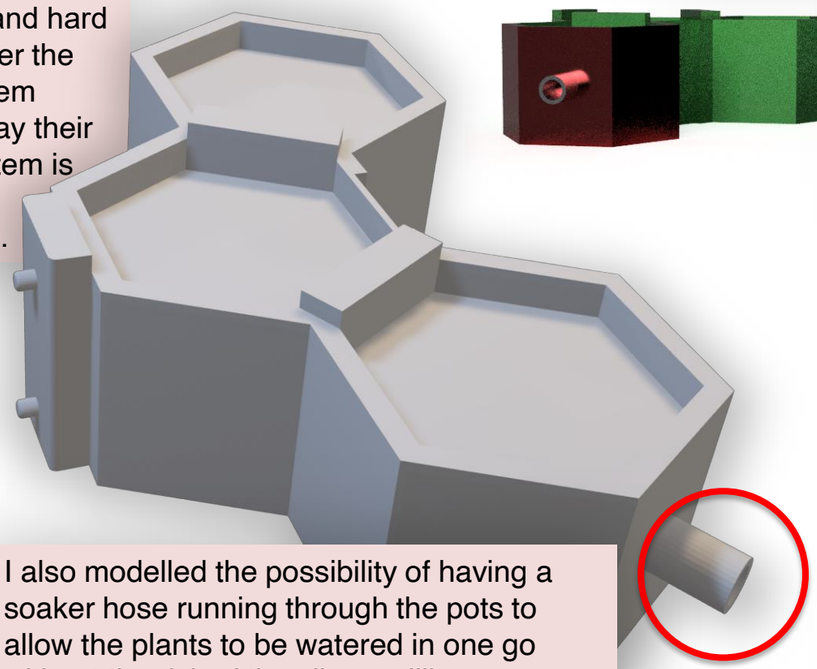


After some initial testing, I found the "slotting mechanism" to be effective. I decided to further improve this design by implementing a more tight fitting slot mechanism which utilizes neodymium magnets to hold the whole product together allowing it to be move around as one whole unit instead of each pot having to be carried individually with risk of it falling apart.

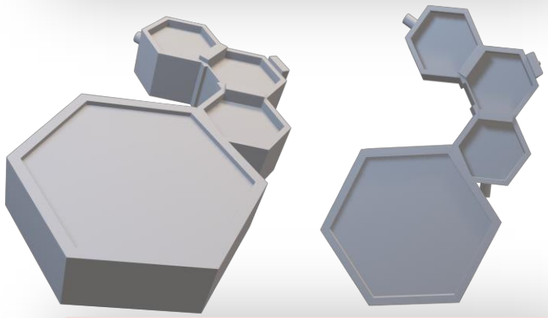




I also experimented with the idea of having a variety different coloured pots being able to be slotted together to allow the consumer to have an element of customizability for the product.



I also modelled the possibility of having a soaker hose running through the pots to allow the plants to be watered in one go without the risk of the client spilling some water
and for ease of use.



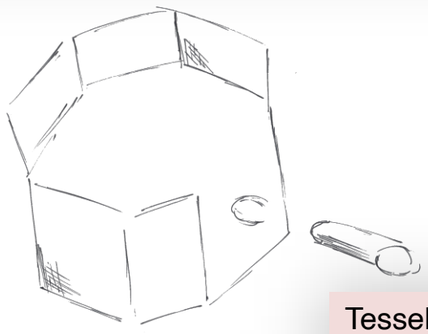
The product could also have different sized pots to allow for larger plants other than herbs to be grown as well. However this made the product much less kitchen friendly as it was considerably more bulky.

Model Development

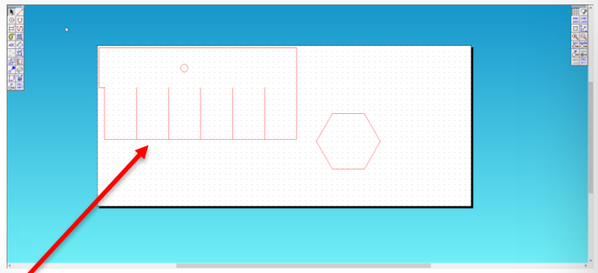
Design 1

Continuing Development of the Model

The client was still unsure on whether the hexagonal pots would suit her kitchen. In the previous slide I have used various methods of CAD development to try and convey my ideas to the client however I felt a real model which she could see might be able to give her a better picture of how it would fit into her kitchen. To do this I used a combination of techniques including CAD, CAM and 3D manufacture to create a demonstration model to show to the client.



Sketch

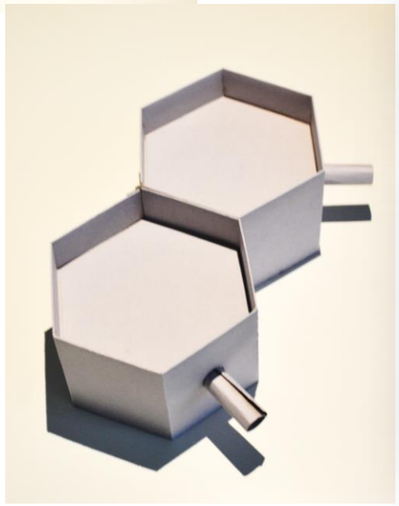


2D Development

Tessellated material to avoid wastage when constructing. Material management is specifically important for reducing wastage/costs.

I used 2D design to model a 3D Hexagon net which I could use on the laser cutter to cut card material which could be formed to create a 3D Hexagon.

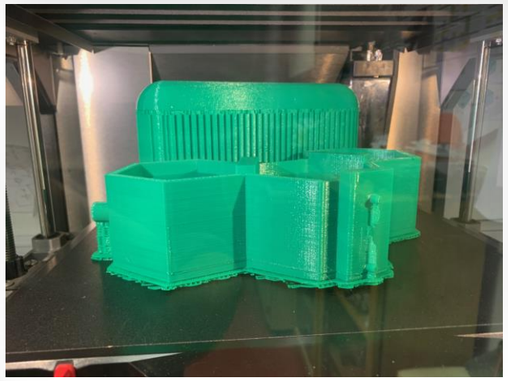
3D Development



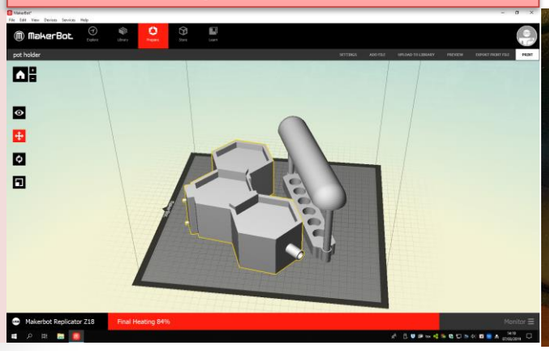
This model looked much better than the foam model I created before. The client understood the idea with much greater clarity.

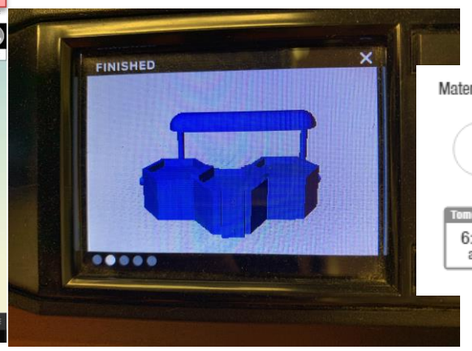
However to fully understand the model, I felt it would be a good idea to 3D print the CAD design I had come up with earlier and position it in the proposed position stated by the client. I setup the STL file exported from Autodesk fusion and laid the model on the bed so it would print in the most effective way with no need for supports.

The 3D print came out well with very few defects. The model was fairly solid (with a 25% infill). The print job took a total of 20 hours and used an estimated 215g of PLA filament which is less than a 1/3 of a spool.



NB: I printed another model at the same time so I could leave it during the school day.





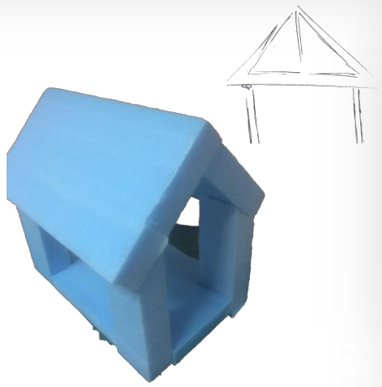
I took the hexagonal pots to the clients home and observed how they looked on the proposed position by client. I immediately realised that the design was slightly flawed for the location (the windowsill) as it was fairly narrow which meant that in some configurations the pots would be leaning over the top causing the product to become unstable. The client said she would prefer if the final product was a bit bigger and asked whether it would be possible to utilise a light somehow in the "roof" of the product.

Developing Design Ideas

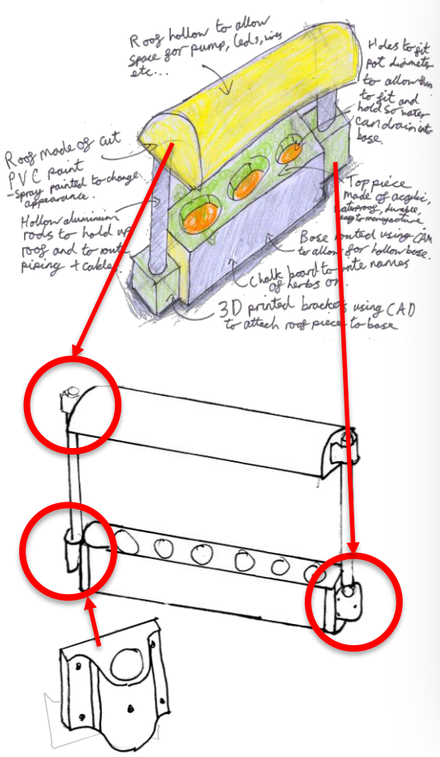
Design 2

Overview of the Design

After developing the modular design of the hexagonal pots, I decided to also explore the idea of having one singular unit that the client could grow their plants in. It has been designed with inspiration from the various indoor gardening products that came up in my research into the work of others. The product is designed to be placed in a kitchen with limited space is supposed to make growing your own as easy as possible. This product incorporates the use of a microcontroller, LED lighting and pump to allow the plant to be self regulating and removes the hassle from the consumer.



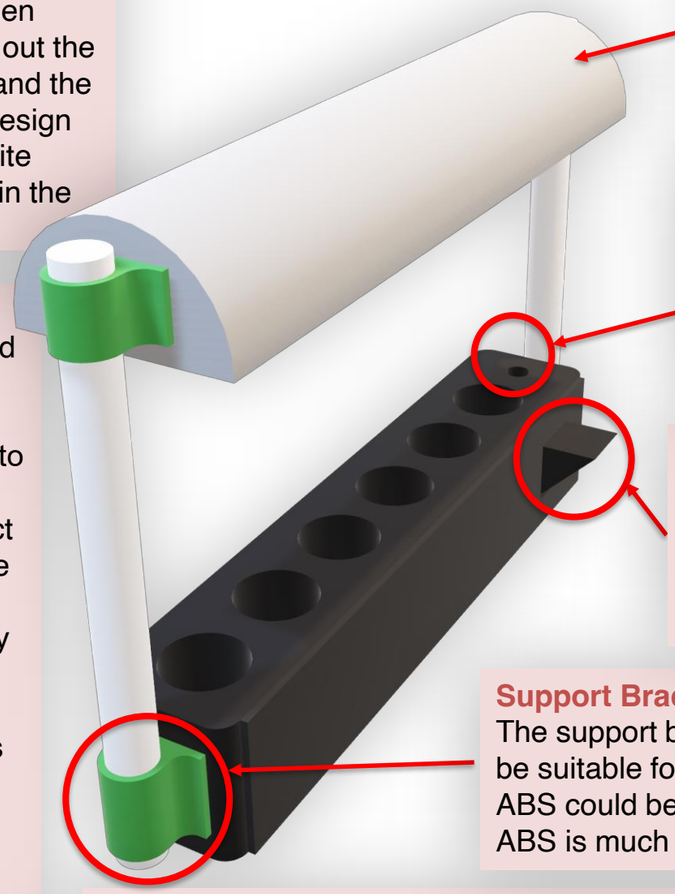
I started initial development of this idea by creating a foam model similar to the sketch of idea 3 I had drawn in the initial design stage. However when showing the design to my peers they pointed out the fact that the plants were not very accessible and the product was not aesthetically pleasing. The design was also not very space efficient as it was quite wide meaning it stood out from other objects in the environment (as the client said it would).



I decided to sketch a more space efficient compact product based off idea 4 which would allow the consumer to display their plants effectively.

- A PVC “roof” is used to allow the product to provide light to the plants.
- I increased the number of pots the product could hold to allow the client to use a wide variety of herbs without feeling restricted.
- I changed the way the brackets worked by moving them onto the exterior of the product to allow for easier manufacture.
- I changed the appearance of the brackets to become more rounded to blend in.

The client approved of these changes and especially liked the idea of having a large number of pots as she current has a large collection of herbs which she would love to organize in a product like mine.



PVC Roof

The roof could be constructed out of PVC. This is an ideal material choice as it is what most common plastic pipes are constructed out of and for the purpose of modelling could be used in my prototype as it is easy to cut.

Water Level Indicator

If I was to use some kind of watering mechanism. It would be ideal for the user to be able view the water level of this mechanism. I came up with the idea of their being a floating object inside a cylinder to indicate this which would raise or lower itself according to the water level.

Watering Mechanism

I experimented with the idea of being able to water the plant pots passively. The water could sit at the bottom of the tray and be somehow transferred to the soil. I will continue development of this idea in the next slide.

Support Brackets

The support brackets are made using CAD and CAM. PLA would be suitable for this purpose as it is only a prototype but in the future ABS could be used if the product was to be taken to market. As ABS is much more durable than PLA.

Client’s Thoughts

The client was pleased with this idea, she felt it suited the environment of her home well, its footprint was small and there was lots of space for her larger plants to grow. She said that for the product she would like the design to follow this idea due to its practicality. This is the idea I will pursue during my NEA.

Developing Design Ideas

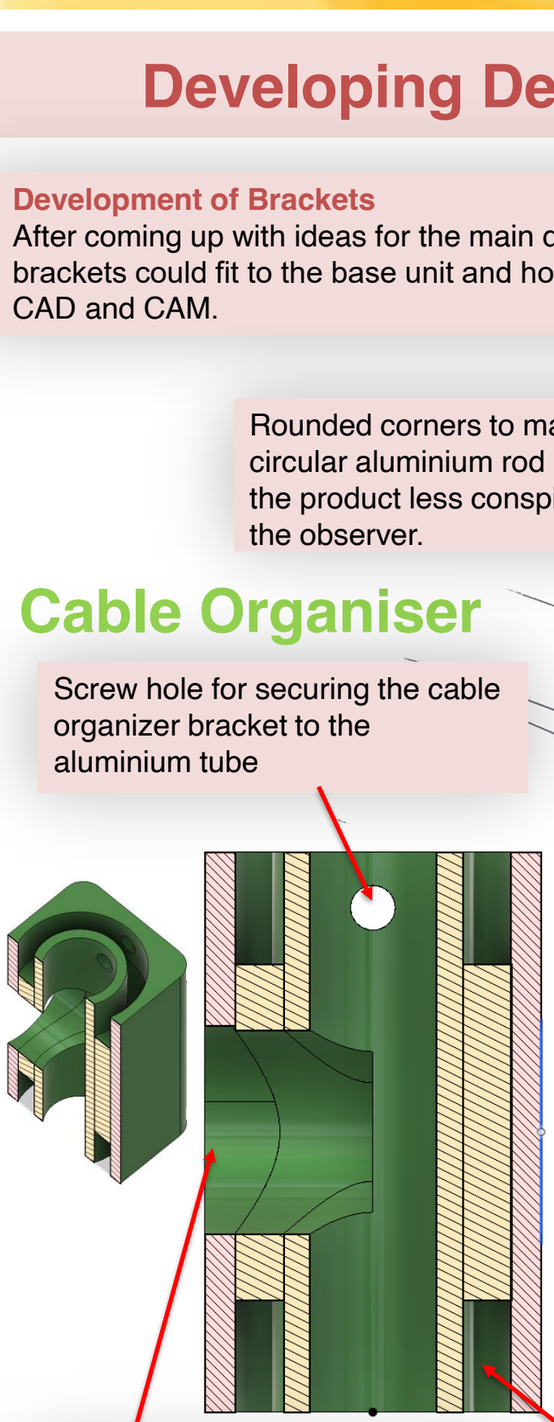
Design 2

Development of Brackets
After coming up with ideas for the main design of the product. I wanted to model the development of the brackets in more detail. I started by sketching out some ideas of how the brackets could fit to the base unit and how they could look. I took into account the client's thoughts of having the product as simplistic as possible. I then went on to model them using CAD and CAM.

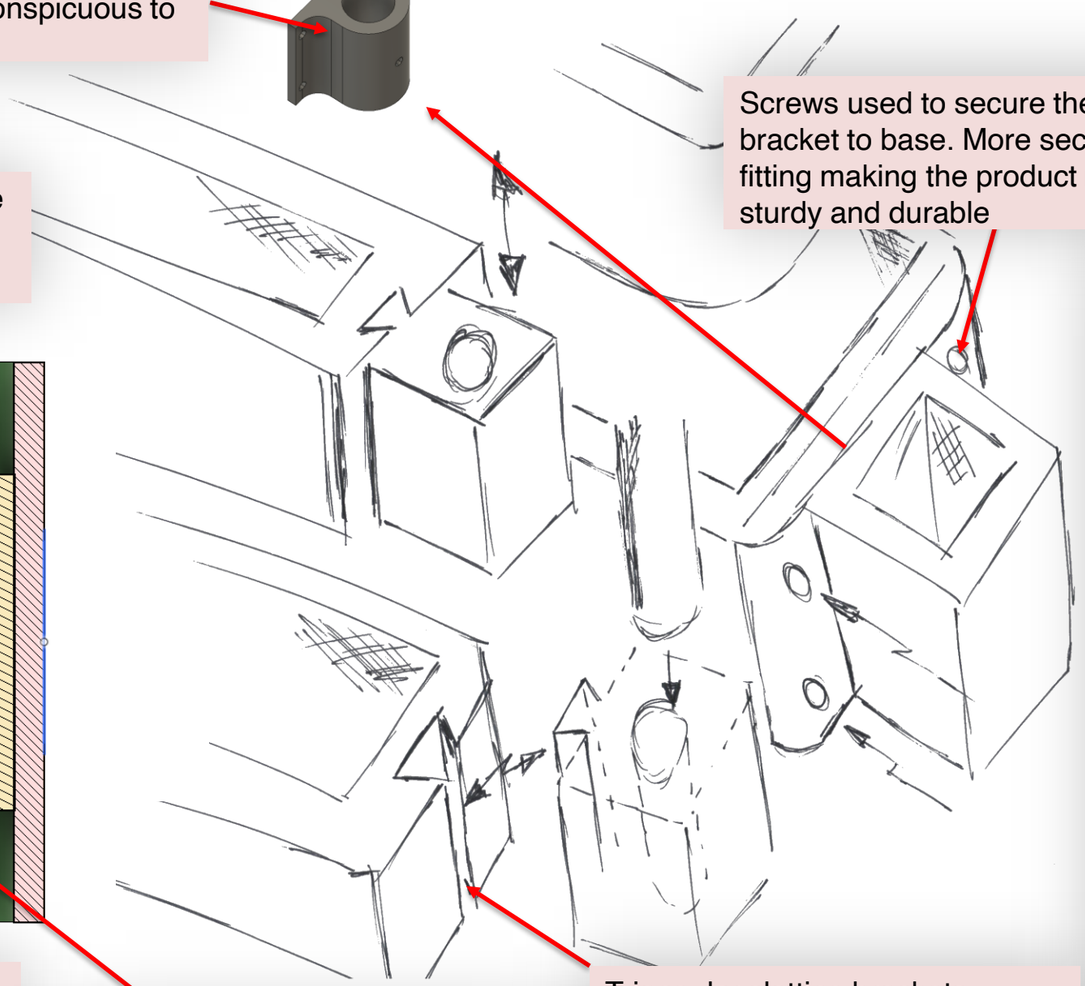
Rounded corners to match the circular aluminium rod making the product less conspicuous to the observer.

Cable Organiser

Screw hole for securing the cable organizer bracket to the aluminium tube



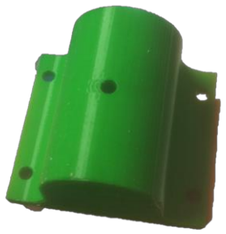
Tube hole for feeding wires and tubing up aluminium pipe.



Slot left for securing aluminium pipe to unit.

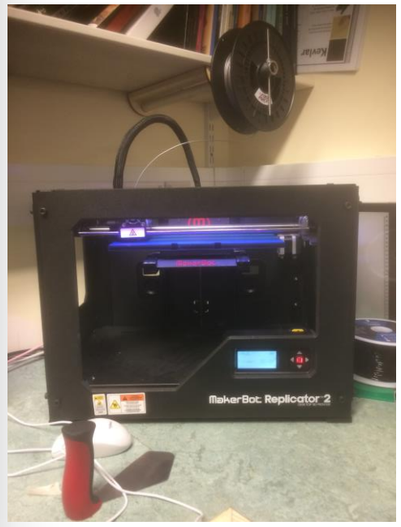
Screws used to secure the bracket to base. More secure fitting making the product more sturdy and durable

Triangular slotting brackets, allows for easy swapping in and out of roof unit when desired.



I modeled the design of the brackets using Autodesk fusion so I could prototype them with 3D printing and so I could use the exact dimensions of the product. I came up with three ideas on the style of bracket.

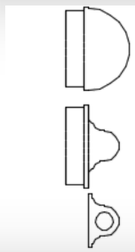
- The first will be used at the base of the product to hold up the PVC roof.
- The second is a concept for how the top bracket should be produced. It is essentially the first bracket placed onto a support structure to hold the roof in place.
- The third is another concept for how the top bracket should be produced. It is rounded off to be more aesthetically pleasing and fit the criteria of the client.

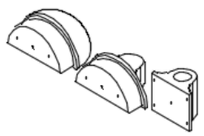


Model Development

Roof Connecting Bracket

After coming up with two ideas for the roof bracket, I modelled two versions that would fulfil the purpose. To see which one worked best I modelled both in Autodesk Fusion 360 (pictured below). I then 3D printed the models using MakerBot print in PLA filament. The model on the left hand side is more rounded to create a smoother transition from the roof to the aluminium rod. The model on the right is based off the bracket on the bottom.



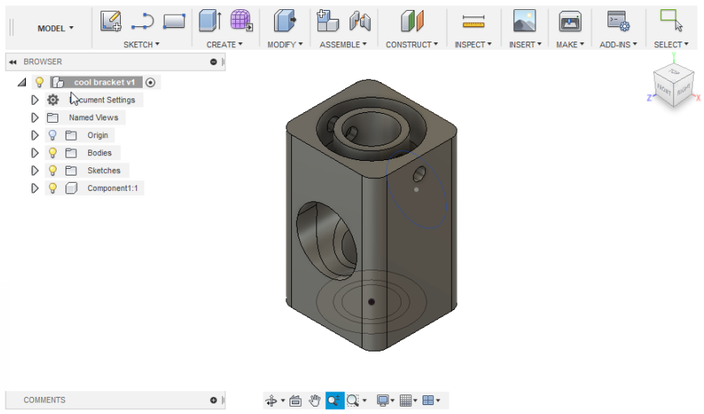


Client's Thoughts

The client preferred the rounded model as she described it as looking less "industrial" and creating less of an impression meaning it would blend in to her kitchen. I will use this bracket design for the final product.

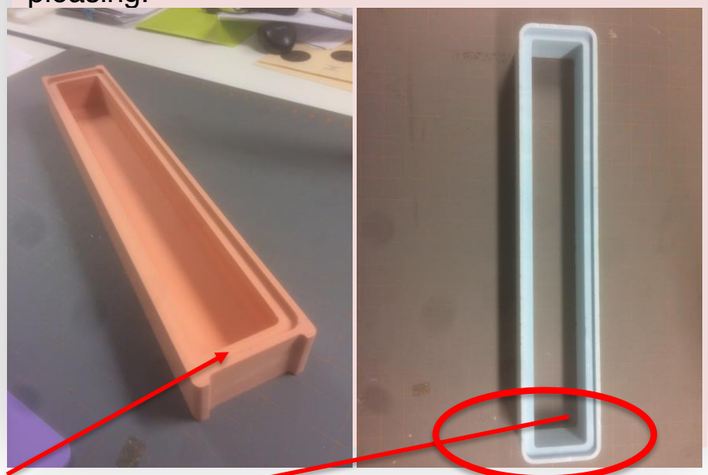
Cable and Tubing Management Bracket

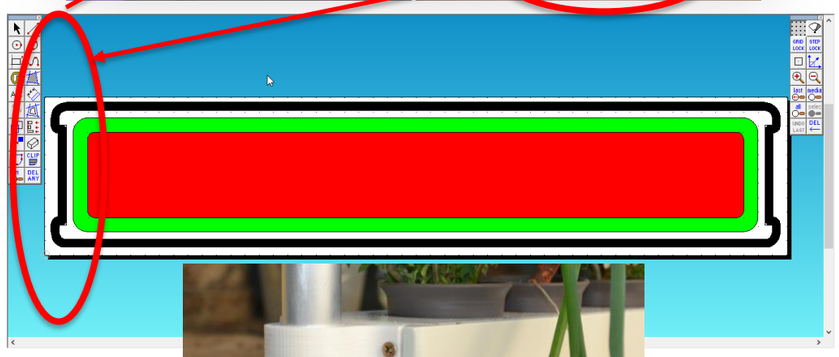
During modelling of my design, I realised that I would need to create some form of bracket to allow the wiring and tubing to pass through the hollow aluminium tube. I initially sketched a basic design idea of how the bracket could fit the two tubes together. After some development, I decided to model the bracket pictured below in Fusion 360. The design is fairly simple but appears aesthetically pleasing and serves its purpose.



Lap Joint for Bracket

After developing a foam model of the base using 2D Design to produce a drawing that could be routed on the 3D router. I realised that screwing the bracket directly onto the end using a butt joint may not be the most aesthetically pleasing or suitable for its purpose of securing the entire weight of the roof onto the product. So instead I modified the drawing to incorporate a lap joint so there was a larger surface area for the bracket to fit on to ensuring it was secure and aesthetically pleasing.





Design Decisions

Materials

Material	Analysis	Cost
PLA Filament	Used for 3D printing, compared to ABS it is weaker however it is much easier to print with due to its low printing temperature. It is also environmentally friendly which suits the criteria of the client.	£17.99/kg
Aluminium	A lightweight material ideal for support structure. It is resistant to corrosion ideal for products which are in frequent contact with fluids. Aluminium is 100% recyclable making it sustainable. It is also relatively durable making it ideal for use in my product. It is fairly expensive in comparison to something like steel.	£7.99 300m length 26mm OD Tube
Acrylic	Used in a Laser Cutter/Engraver to create highly accurate 2D shapes. It is fairly easy to scratch and isn't very durable so it is not ideal for main support structure. It comes in a variety of colours and is resistant to corrasion, water and UV light (sunlight).	£16.50/m^2
High Density Modelling Foam (HDF)	Ideal for use with a 3D router. HDF has good impact resistance and is easy to cut into using a drill bit. Allowing it to be shaped into a wide variety of shapes. CNC routing does have the limitation of not being able to be cut with a flat edge, each corner is curved due to the rotating drill bit.	500mm x 1500mm £80
PVC	PVC is a durable material resistant to processes such as rusting and corrasion. It is also fairly cheap and lightweight. However PVC is prone to breaking under a large impact force.	£7.99 300mm length 100mm OD Tube

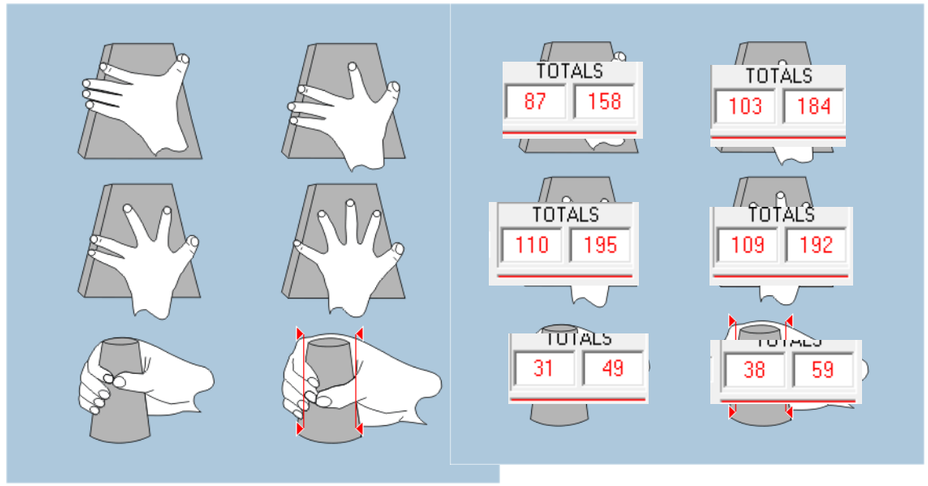
Client's Thoughts

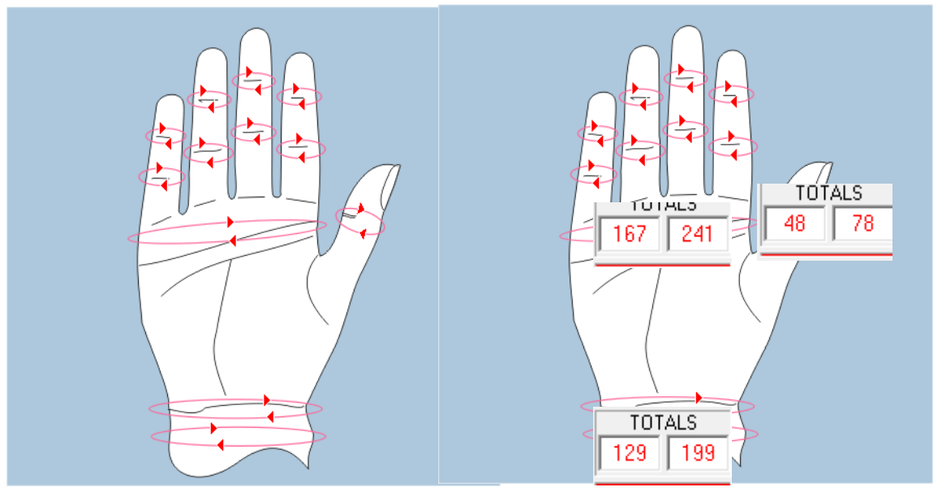
The client approved of the material choices specified above. She did have a comment on why wood was not utilized in the design but then understood once I had explained that this would significantly increase the cost of the product. She liked the idea of the aluminium support structure alongside the coloured base and roof unit.

Ergonomics

Evaluation of Ergonomics

I collected the following Anthropometrics to work out how to achieve good ergonomics within my product. I will use these to influence the size of the pots and other utensils used with the product.





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Testing of Electrical Concept

Overview of Testing

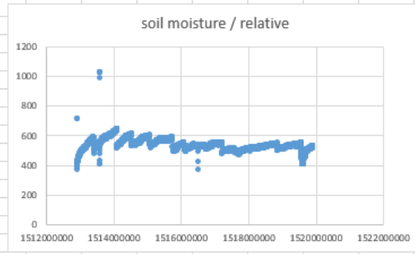
In order to test the functionality of my product, I created a circuit with a microcontroller which enabled me to test and monitor the growth of the plant. Allowing the plant to be cultivated independent of any human interactions.

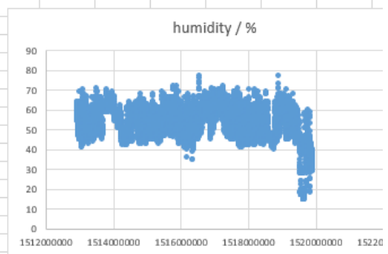
- For the prototype of the system, I used a laser cut plastic frame with a grid of holes allowing the plant to grow out.
- I used LED strips to supply lighting towards the plant.
- I used a Raspberry Pi to control the various sensors and outputs which was connected to the internet allowing the user to monitor remotely.
- I had a reservoir of water connected to a pump via plastic tubing allowing the water to be pumped from the tank to the plant.

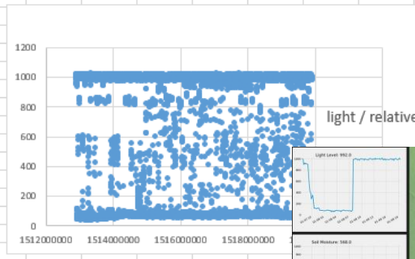
Results of Testing

Pictured to the right is the collection of data stored on the database within the microcontroller when monitoring the plant. It shows the soil moisture, light level, temperature and humidity % over a period of time. The microcontroller took a reading every 10 minutes and wrote it to the file.

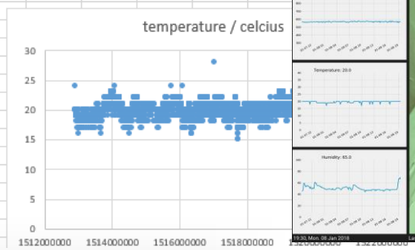
timestamp	soil moisture / relative	light / relativ	temperature	humidity / %	lastwatered
1512929628	706	1012	20	64	1512929602
1512929659	709	1010	20	63	1512929799
1512929793	706	996	20	63	1512929799
1512929883	369	989	24	61	1512929799
1512930011	375	987	20	63	1512929799
1512930611	386	1010	20	63	1512929799
1512930915	397	997	20	62	1512929799
1512931006	397	1013	20	61	1512929799
1512931137	404	1009	20	61	1512929799
1512931209	401	975	20	61	1512929799
1512931248	399	993	20	61	1512929799
1512931322	405	1012	18	62	1512929799
1512931404	398	998	19	61	1512929799
1512931478	402	987	20	61	1512929799
1512931573	408	994	20	61	1512929799
1512931811	406	1005	20	61	1512929799
1512932411	405	993	20	60	1512929799
1512933010	410	996	20	60	1512929799
1512933610	413	1009	20	59	1512929799
1512934210	416	1006	20	57	1512929799
1512934810	416	999	20	57	1512929799
1512935411	411	1002	20	57	1512929799
1512936010	414	954	20	56	1512929799
1512936610	418	957	20	60	1512929799
1512937211	414	954	20	64	1512929799
1512937810	417	949	20	62	1512929799
1512938410	417	935	20	61	1512929799
1512939010	421	949	20	60	1512929799
1512939611	419	953	20	60	1512929799
1512940211	415	947	20	59	1512929799
1512940811	415	949	20	59	1512929799
1512941410	424	947	20	59	1512929799
1512942010	415	101	20	58	1512929799
1512942611	422	109	19	57	1512929799
1512943211	425	102	19	56	1512929799
1512943810	423	109	19	56	1512929799
1512944410	426	104	19	56	1512929799
1512945010	427	102	19	56	1512929799
1512945610	423	109	19	55	1512929799
1512946211	423	106	19	55	1512929799
1512946810	429	107	19	55	1512929799
1512947411	423	79	19	54	1512929799

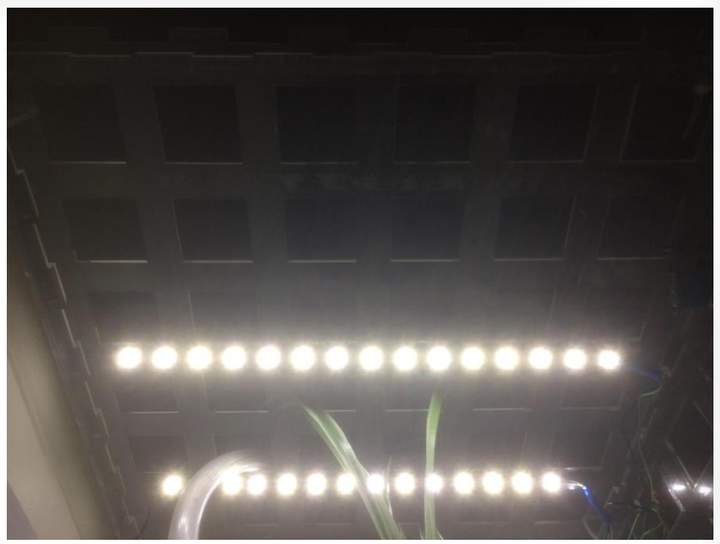






light / relative





Images of Testing

Pictured to the right are two of the thousands of images taken by the Raspberry Pi.

- This was taken automatically using a camera connected to the microcontroller.
- The microcontroller appended graphs and timestamps to the photos so the user could tell how their plant was doing.

Evaluation of System

This system will be employed within the final product that will be taken to market. For mass production the circuit will need to be produced onto a PCB allowing the components to have a reliable connection. All the components work in conjunction with each other to work out when the plant needs water and when something requires the owners attention. It has full connectivity with the internet allowing it to be viewed across the world. The system is all low power meaning it does not pose an electrocution risk.

Plan of Manufacture

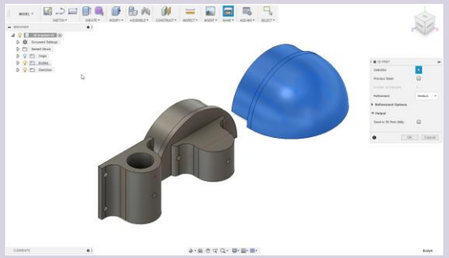
Process	Start Date	End Date	Quality Control	Risks	Comments	Time
Create CAD Models and 2D Design files to along with them. Generating renders to present to client	8th November 2018	22nd November 2018	Ensure measurements are accurate according to client's specification	Eye strain from using a computer. Fatigue for working for long periods of time. These can both be resolved with frequent breaks.	Finished faster than expected. Completed by 16/11/2018. The models came out high quality and all was ready for manufacture.	4 Hours
3D Routing – Base Structure	25th November 2018	29th November 2018	Ensure that cuts are clean and smooth. If not sand off.	Ensure that I do not inhale too much dust when cleaning out the router.	Finished on time. Unfortunately base was not routed with right dimensions due to being accidentally stretched in 2D design so had to be redone.	3 Hours
Spray Painting – Base Unit	3rd December 2018	6th December 2018	Ensure that unit is sanded before coating. Go over again if any inconsistencies.	Ensure I do not inhale fumes and do not get paint on skin/clothing.	Finished on time. Coat dried quickly allowing for the process to be turned around quickly.	20 min labour (6 hours waiting)
Laser Cutting – Base Unit and Base Protector	7th December 2018	10th December 2018	Ensure that laser cutter is properly focussed so the laser cuts accurately.	N/A. The laser cutter has safety features built in to ensure that the laser can never come into contact.	Laser cutter was very accurate. Job was done very quickly. No issues.	20 min
3D Printing - Brackets	11th December 2018	12th December 2018	Ensure that bed is flat to allow filament to settle correctly. Place tape on bed for secure fit.	Don't touch extruder while it is working as it heats the filament to extreme temperatures to allow it to be extruded.	Check measurements at end with digital callipers to ensure print has come out correctly with no scaling.	20 min labour (18 hours waiting)
Attaching Base Protector and Brackets to Base	13th December 2018	14th December 2018	Ensure screw is flat with surface of bracket so it inconspicuous.	Make sure not to touch spinning drill bit. Have both hands on body of the drill to ensure this does not happen.	Finished on time. Some screws took a bit of effort to get in straight. Required quite a bit of care, would not be suitable for mass production.	30 min
Cutting and Brushing Aluminium Rods	18th January 2019	23rd January 2019	Ensure both rods are same length with digital callipers.	Ensure hands are kept well away from hacksaw blade to prevent injury.	Completed on time. One rod was not cut straight meaning sizing was different which meant it had to redone.	30 min

Plan of Manufacture

Process	Start Date	End Date	Quality Control	Risks	Comments	Time
Cutting Down PVC Pipe	24th January 2019	28th January 2019	Verify length using meter rule to ensure it will fit within brackets.	N/A being performed by trained personnel who know how to use the band saw safely.	Finished as expected.	2 min
Spray Painting – PVC Pipe	29th January 2019	30th January 2019	Ensure that unit is sanded before coating. Go over again if any inconsistencies.	Ensure I do not inhale fumes and do not get paint on skin/clothing.	Finished on time.	20 min labour (6 hours waiting)
Attaching Bracket to PVC Pipe	1st February 2019	4th February 2019	Ensure that screws are straight. Make sure they are flat with surface of bracket.	Make sure not to touch spinning drill bit. Have both hands on body of the drill to ensure this does not happen.	Finished on time. No problems apart from one screw struggling to go in which needed me to screw a hole slowly which it could then fit into.	20 min.
Slot all components together and fasten.	4th February 2019	8th February 2019	Ensure that measurements match up with CAD model orthographic sheet.	Watch for any sharp edges, if there are any sand them down.	Finished on time. No problems apart from aluminium rods needing some turning within the brackets to ensure a smooth fit (due to the rough edge from 3D printing).	40 min

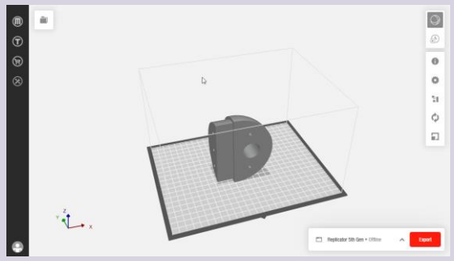
3D Manufacture Software Setup

Fusion 360 Design



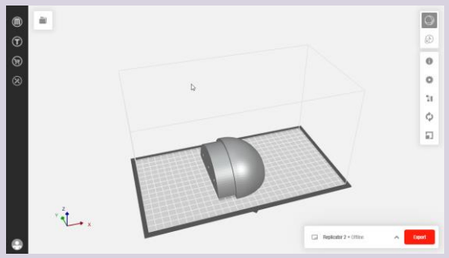
I used Autodesk Fusion 360 to generate my models as it is fairly simple to use and produces high quality models which can easily be exported to STL files which can be understood by almost all 3D printers. I selected the relevant bracket model I wanted to print and clicked the “Make” button in the toolbar. This would then generate the STL file for the model and be saved in my documents folder.

MakerBot Print (STL)



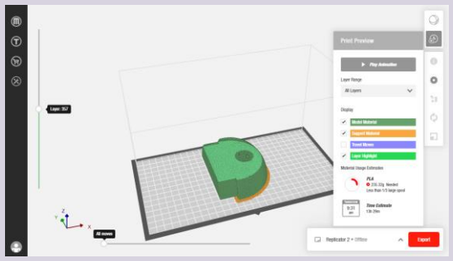
I could then import the STL file into MakerBot print to be converted into code which the 3D printer could understand. I setup a build plate and dragged the model in by using the STL file I created earlier.

MB Print Adjustment



I needed to setup the build plate to work correctly with my 3D printer (the Replicator 2). I setup the MakerBot software to treat the printer as unconnected so it could generate the correct file format that the printer could understand. I also had to make sure the bracket piece was orientated correctly so it would print in the most efficient way without the use of supports. This means there is little material wastage.

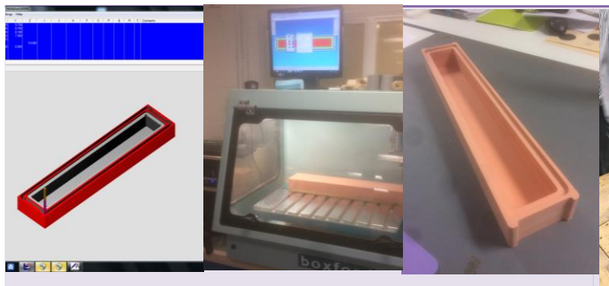
File Export (X3G)



The Replicator 2 uses an X3G file. The X3G file contains all the information the printer needs including movement instructions and support information (such as extruder temperature). I exported the file and placed it on an SD card ready to be inserted into the 3D printer and printed from. Pictured above is the print preview from MakerBot print. The estimated print time generated by the software was 13h.

Diary of Manufacture

1. Routing Base



Routing the base using a 2D sketch drawn in 2D design with varying depths which was then used by the 3D router to drill and route the model. I used HDF as my material. I placed wood on the bottom of the material to ensure that the router did not drill through and cause damage to the bed.

2. Spray Painting Base

I sanded down the HDF to ensure that it had a smooth finish ready for it to be spray painted. I first used an undercoat spray paint to ensure that the colour came out smooth and bright. I could not sand the inside of the base due to poor accessibility however this does not really matter as the user will never see it in that much detail.

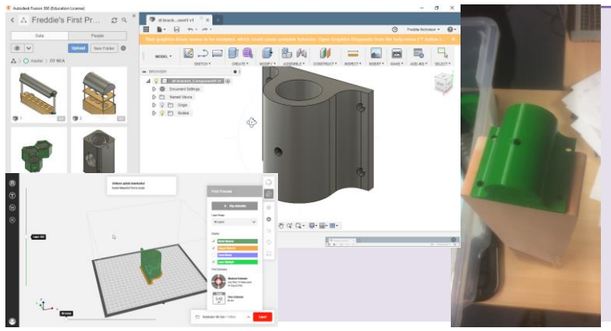
3. Laser Cutting Base Protector and Pot Holder

I used a laser cutter to cut the acrylic that I would use as a pot holder. The drawing was again drawn in 2D design and sent to the laser cutter to cut. To define to the laser cutter that the material needed cutting I used a red outline which then adjusts the power of the laser causing it to cut the 5mm acrylic.

4. Attaching Protector to Base

I attached the base protector to the base using double sided tape. Although this is not the best solution it is fine as the product is only a prototype. If the product was to be manufactured, a strong adhesive could be used to secure the protector to the base. I also placed protective feet on the base to prevent the acrylic from scratching.

5. 3D Printing Brackets



I modelled the brackets in Autodesk Fusion 360 using the exact measurements that I used for the base unit. Due to the timeline feature in Autodesk Fusion 360 this is particularly easy as I can just edit one measurement and it will be reflected in the rest of the model. I used MakerBot Print to convert the STL file into a printable format.

6. Attaching Brackets to Base

I attached the bracket to the base unit using 4mm diameter screws with a countersunk top so the screw would sit flush with the bracket. I fitted the screws to the bracket and base using a power drill. I had to take care to make sure that the screw was going directly straight otherwise I could have caused damaged to the base/bracket.

7. Cutting Aluminium Rods

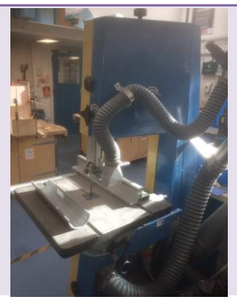
I cut the aluminium rods using a hacksaw. I mounted the aluminium rod in the metal working vice and continuously sawed until the end came off. I then sanded the end of the pipe to give it a flat edge to fit inside the bracket. One rod needed to be cut in two to fit a cable organiser in the middle which will be used to route cables and tubing.

8. Brushing Aluminium Rods

I used wire wool to brush the aluminium and give it a shiny effect. I continuously brushed up and down in the same direction all around the aluminium rod to achieve the effect and to make sure it was continuous.

Diary of Manufacture

9. Cutting Down PVC Pipe



Mr Hughes assisted me in cutting down the PVC pipe on the band saw as it is for use by trained personnel only at our school to prevent a risk of injury. I measured the required width using a steel rule and getting the length between the two brackets mounted on the aluminium rods. I then marked this on the pipe.

10. Spray Painting PVC Pipe

Similar to how I spray painted the Base unit. I applied an undercoat to the PVC pipe and then added the white coloured coating. The material this time did not need sanding down as it was already smooth enough to be suitable for spray painting.

11. Attaching Bracket to PVC Pipe

I used three 5mm screws on each side of the PVC pipe to secure the roof to the brackets on each side. I had to make sure that I drilled the screws in straight due to the narrow gap between the bracket and the fitting underneath.

12. Slotting Everything Together

Finally to complete my product, all I needed to do was slot everything together. This was the easiest stage. I then secured the various brackets together using the various screw points I had left in the 3D printed parts to allow all the components to be secured together.

Tools used in Manufacture

MakerBot Replicator 2

I used the MakerBot replicator to 3D print my models used in this design. It is known for its ease of use which is why it is popular amongst schools. Files can be directly exported from Fusion 360 ready to print very quickly which makes it ideal for the prototyping workflow of my DT NEA. It can print in a wide variety of materials including PLA, ABS and flexible filament.

MakerBot Print

The software used to convert 3D models from fusion 360 (STLs) to 3D printer code (x3gs).

Boxford Router

The 3D router can be used to cut and create components in a wide variety of materials. It is designed for use in education and is therefore very safe to use. The router accepts a wide variety of file formats meaning the software that is used for our laser cutter can also be used for the router. I used the router to print my base unit for my product.

Laser Cutter/Engraver

The laser cutter can be used to cut/engrave material using 2D files sent from a computer. It is much faster than something like a 3D printer/router which makes it ideal for prototyping.

Software

Autodesk Fusion 360

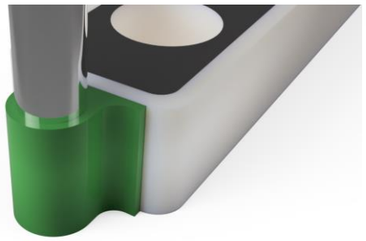
I used Autodesk Fusion 360 to create my models for the 3D Printer. It is very easy to use due to its “sketching” and “timeline” capabilities.

2D Design

2D design is a 2D imaging manipulation program that uses real world units to create drawings which can be fed into CAM equipment. It is designed for use by students like me.

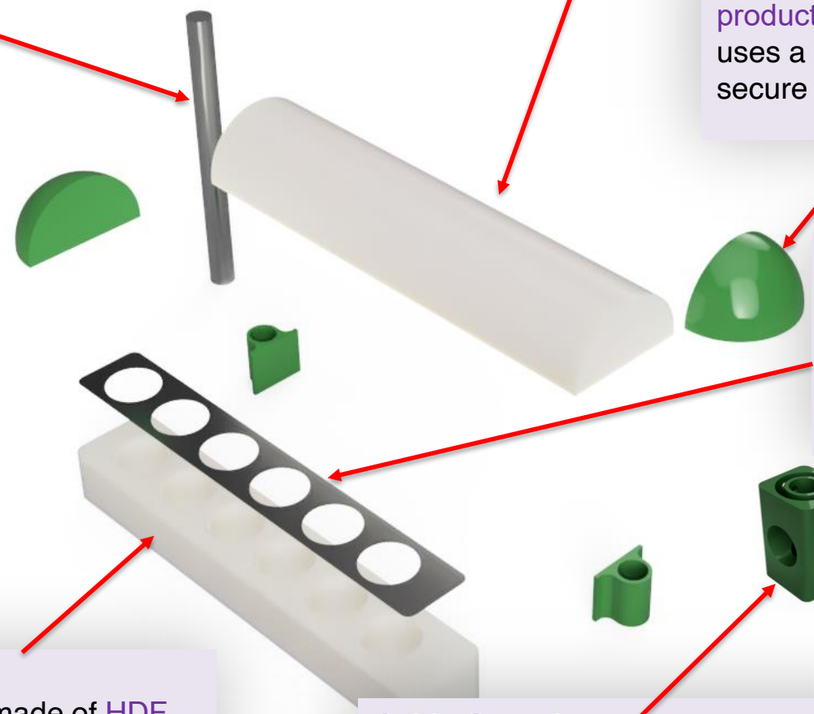
Final CAD

Product View



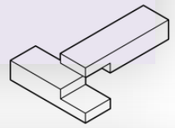
Aluminium Rod
The aluminium rods provide support for the roof unit. Wires are also routed through them.

Exploded View



Roof
The roof is used to contain all the products electronics, wires are routed through the roof brackets and down the aluminium rod.

Roof Bracket
The roof bracket is used to connect the product's roof to the aluminium rod. It uses a lap joint to join them meaning a secure fitting is made



Pot Holder
The pot holder is a length of 5mm acrylic with laser cut holes for the pots to rest in. It is designed to be removed and replaced by the client.

Base Unit
The base unit is made of HDF and provides the main support for the product. It is hollow on the inside to allow for drainage outside of the pots.

Cable Organiser
The cable organiser is used to route the cables and tubing out of the aluminium rod and into the various appliances required.

Conclusion
My final 3D CAD drawing of my design was drawn in Fusion 360. It combines all the features of my product which I found to be most suitable from my model development. It carries all the necessary features required to fit the electronics system which I have prototyped to place inside my product. Cables can be routed throughout the product without being seen as well as tubing for the water supply for the product. There is a curved roof for the lighting units/pump to be fitted and a base unit for the pots to be placed and allowing them to have sufficient drainage. The unit is held together securely and no parts are left "floating" apart from the pot holder which is intended to be removed and replaced as the client changes the plants/herbs she is growing. To the right, you can see a ACCESS FM chart I made around the products overall effectiveness. As you can see, most areas of the product are rated highly. The cost is at the lowest value but this is due to the sustainable materials used and the slow manufacturing processes such as 3D printing which could be resolved if the product was to be put to market.

Final Materials List

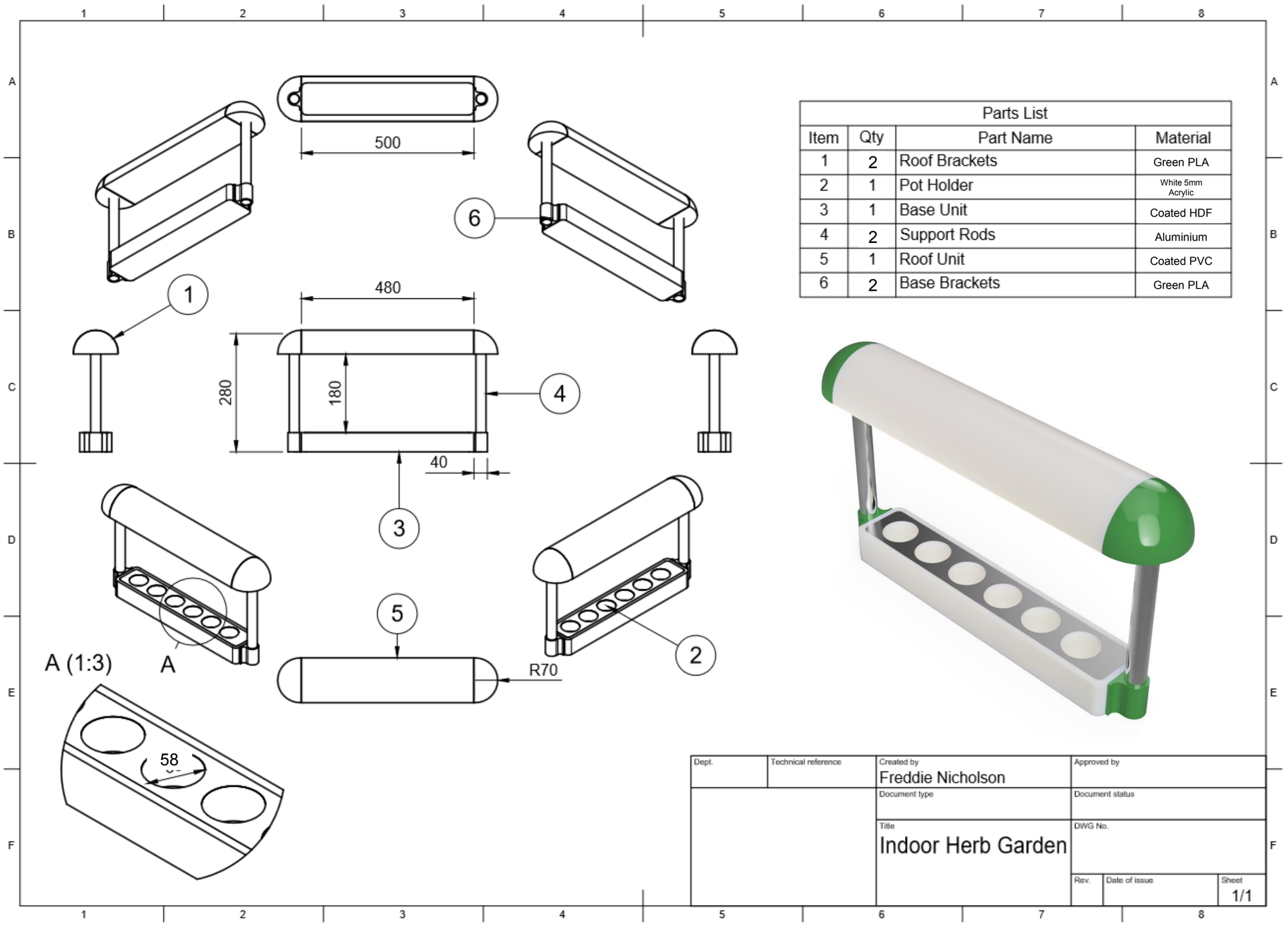
Qty	Material	Usage	Unit Cost	Relevant Dimensions	Total Cost
560g	Green PLA Filament	Brackets for product	£17.99/kg	n/a	£10
2 * 180mm	Aluminium Rods	Support Structure	£7.99 300m length 26mm OD Tube	2 * 180mm = 360mm	£9.58
480mm	PVC Pipe	Roof Structure	£7.99 300mm length	100mm OD	£12.78 (£6.40 if halved)
62mm x 580mm	Acrylic	Pot Holder and Base Protector	£16.50/m^2	5mm thickness 35.96cm^2 * 2 for base protector	£11.80
192cm^3	High Density Modelling Foam (HDF)	Base Unit	500mm x 1500mm £80	500mm x 64mm x 60mm	£20.48
5	4mm Countersunk Screw	Fixing brackets to structure.	£1.89 per 25 pack	n/a	£0.04
6	6mm Hex Nut	Hold screw together for roof unit.	£0.77 per 20 pack	n/a	£0.02
6	6mm Screw	Secure roof unit to bracket.	£5.49 per 20 pack	n/a	£1.65

Manufacturing Specification

- **Use PLA, ABS or Aluminium for Brackets**
- **Use HDF or Hardwood for Base**
- **Use Acrylic for Pot Holder and Base Protector**
- **Use CNC Machine or 3D Printer to construct Brackets**
- **Use Laser Cutter/Engraver for Pot Holder**
- **Use brushed aluminium rods for support.**

Total Cost: £59.97

Working Orthographic

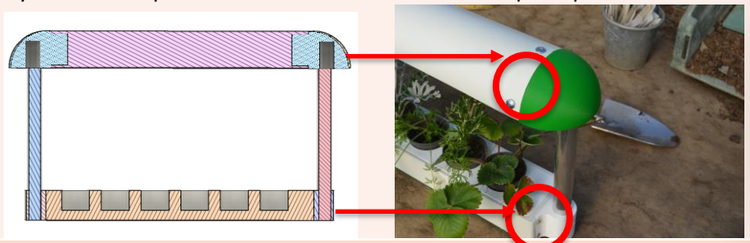
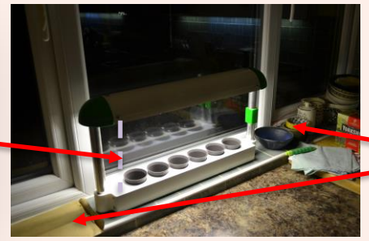


Parts List			
Item	Qty	Part Name	Material
1	2	Roof Brackets	Green PLA
2	1	Pot Holder	White 5mm Acrylic
3	1	Base Unit	Coated HDF
4	2	Support Rods	Aluminium
5	1	Roof Unit	Coated PVC
6	2	Base Brackets	Green PLA

Dept.	Technical reference	Created by: Freddie Nicholson	Approved by
		Document type	Document status
		Title: Indoor Herb Garden	DWG No.
			Rev. / Date of issue / Sheet: 1/1

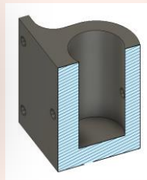
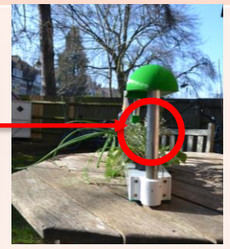
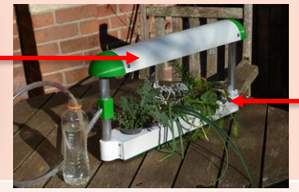
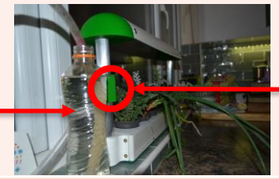
Comparison to Specification

Design Specification

Specification	Achieved?	Analysis
The product's colour palette should match the client's kitchen. The client's kitchen has mainly monotone colours so it would be more suitable to have colours that follow this theme. The client has said that any colours which follow the theme of a plant (e.g. brown/green) are acceptable as well.	✔	The products colours consist of: White, Green and Silver. These all fall within the specifications criteria meaning the product fulfils this criteria. The silver does give a metallic feel to the product so perhaps if I had more time I could use a powder coated variant. **Joseph Joseph Colours** As stated before, my client liked the Joseph Joseph colours so I ended up using them in my final product.  **Aluminium Rods** I used aluminum for the rods as I felt it was the most aesthetically pleasing material that could fulfil the purpose of rigid support. It is also light weight.
Any joints that join two materials together should be unnoticeable or hidden away to make the product appear more aesthetically pleasing to the user.	✔	Many lap joints are used which mean the joint is completely unnoticeable to the standard user. Some screws are used but this are barely noticeable apart from the ones on the roof which perhaps could have a thinner diameter for production.  **Lap Joints** As you can see from the 2D section analysis picture to the left. There are several examples of lap joints being used to create a secure fitting which are barely noticeable in the picture to the right.
Any piping/cabling for the product's lighting and water should be hidden from view to make the product appear more aesthetically pleasing and to make the product fit in the client's kitchen.	✔	The use of a cable organiser to route the cables and the hollow tubing allows for all cabling to be routed without the user ever seeing them.
The whole product should fit in the space the client has provided of 66mmx500mmx430mm. It should use the space as efficiently as possible to allow the client to grow as many herbs as possible.	✔	The product fits within these dimensions and uses space fairly effectively. There is quite a big use of vertical space however in the clients kitchen this does not matter. **Vertical Space** There is a lot of space for growing plants. As you can also see from this picture, there is nothing in this space due to it being a window so this usage does not matter.  **Space Management** Lots of space available for clients own items so the product can fit into their lifestyle without being intrusive.
Any holes that will contain the pots need to be 58mm in diameter to allow the pots to fit snugly. The pot size for the product must be 65mm x 65mm with an outer diameter at the top of 64mm. From my research, I have found that by investigating several pot sizes, this is the ideal size for growing herbs.	✔	All the holes in the Pot Holder unit fulfil this criteria. This means that the pots fit snugly. If mass produced, the product could be designed for a variety of pot sizes.
After speaking to the client, I have understood that the suitable number of pots for her herbs would be 6. This will allow the client to grow a variety of herbs. This amount of pots also means that the pots would fit in the dimensions given by the client.	✔	The product can store 6 pots as stated in the specification. Perhaps if the product was to be produced, manufacturers could look into ways of allowing the product to be resized according to the customers requirements.

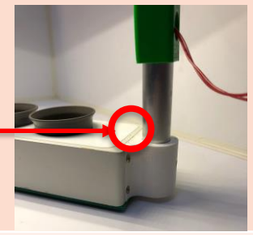
Comparison to Specification

Design Specification

Specification	Achieved?	Analysis
The plants should be able to grow with sufficient space. From my research, I have been able to gather that the average herb requires at least 70mm radius laterally and 100mm of space upwards to grow effectively.	✔	The plants have a space of 180mm by 100m to grow which is more than enough for the client's requirements.
The product must be able to stand itself upright. I will have to make sure that the product is not top heavy during construction which could lead to the plant pots becoming damaged if the product is unstable.	✔	The product can support itself fine with the aluminium rods providing rigid support. **Brackets** All the brackets used in the product have low tolerances so the rod would fit snugly.  **Aluminium Rods** The aluminium rods are used to support the structure. They are slotted directly into the brackets for a rigid structure. 
The product will be fitted with a lighting system to allow the plants to grow out of the presence of sunlight. The client said this would be extremely useful as natural light in her kitchen is hard to find.	✔	The product is fitted with cool white LED strips as chosen in the context specific research. The user is able to turn these off by the power supply at the wall. They are fitted in the roof unit.
The product will run off a low voltage USB power supply. This will mean the product is convenient to set up as most people have several USB charging points around the home	✔	The LED strips are 5V which is the working voltage of a USB power supply
The product will be fitted with a roof for aesthetics purposes and to protect the plants from the elements when outside.	✔	The roof was constructed and fulfils the purpose the criteria set it out to do. It is made of PVC which means it is protective against damage. It is also waterproof. **Weather Resistant** The PVC material did not show any signs of wear after weeks of usage, as you can see from the photo.  **Acrylic Pot Holder** The pot holder did show some signs of usage with soil covering the top but this could quickly be wiped off with the hand.
The product must be able to support the plant pots for a long period of time.	✔	There is no reason the product would not be able to store pots for a long period of time.
The product will be fitted with a pump connected to a tank to allow the user to quickly water the plant pots.	✘	Although this mechanism was made as a prototype, it was never actually fitted due to underestimating the time required to create such a feature.
The water tank connected to the pump mechanism must be easy to refill. It should not need any prior knowledge to operate.	✔	The water tank is a standard plastic water bottle that can be bought off the street meaning it is flexible in terms of size and cost. **Water Bottle** The water bottle is used as it is simple to insert the tube into and is easy to find.  **Acrylic Pot Holder** The cable organiser bracket routes all the tubing and wiring effectively to the roof unit where it can be fed into the pump unit once fitted.
Any electronics used in the product should be low voltage and carefully routed to avoid any contact with water from the pump system.	✔	The electronics in the product all run at 5V meaning there is no risk of electrocution to the client.
All piping should be adequately sealed to avoid any leakage.	✘	As stated above, the pump mechanism was not fitted into the product due to time constraints.
All piping should be adequately sealed to avoid any leakage.	✘	As stated above, the pump mechanism was not fitted into the product due to time constraints.

Comparison to Specification

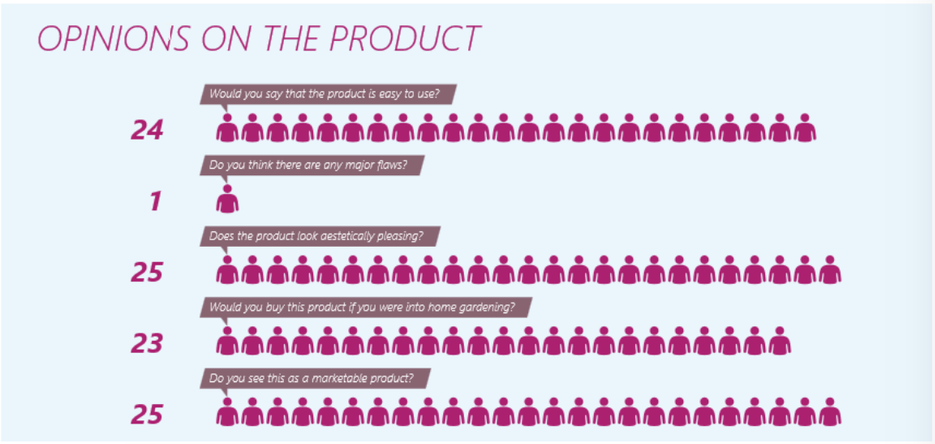
Design Specification

Specification	Achieved?	Analysis
Any surfaces that could come into contact with soil and water should be adequately waterproof so the products colour will not degrade over time. This is also important for when the product may be placed outside	✔	All surfaces have either a finish of some sort or the material is naturally waterproof meaning water cannot get into the internals of the product. The spray paint used is highly durable and designed for outdoor products such as this. **Signs of wear** In person, some dirt is located around this location due to the client repotting plants and moving them around however in this photo it is barely noticeable which shows how minor the wear is. I feel my product would be fine for several years before problems would arise due to the use of HDF. 
The user should be able to switch out plant pots with ease and limited hassle.	✔	The pot holder is very simple to use and effective in its design. The space above allows for lots of room to manipulate the pots and change them around with relative ease.
The product should have some form of labelling system so the user can know what each pot is growing.	✔	Unfortunately, I did not have the materials to fit a chalk board as planned. However the surface of the base is writable with whiteboard markers so this is sufficient to fulfil the criteria.
The product should be flexible in where it can be placed and should therefore not conform to any style to suit one particular location.	✔	The product is simplistic in design meaning it is able to be placed in a wide variety of locations. The colours of the product are subtle meaning it fits most environments.
The product will be made of materials which the client has approved. This includes a form of hardwood for the base, two aluminium rods for support and a styled plastic roof.	✘	The base is not made out of hardwood as initially planned due to the high cost that this would incur. However all the other materials were used to produce the product.
All my materials should be sustainably sourced so if the product was to be mass produced there would be no supply issue.	✔	The PLA we use at school is biodegradable. Acrylic lasts a long time once it is produced meaning it will likely never need to be placed. Aluminium is easily recyclable and lasts a long time.
The products material cost should be under £15, from my context research I have found that the average material cost for a similar product is around this range.	✘	Due to me making this on my own using materials around the school workshop, the material cost was high. However if the product was to be mass produced, many of the materials on my product could be purchased under a bulk order or substituted for a cheaper alternative.
All surfaces should be made of some form of waterproof material or finished. This will allow the product to be used outdoors and also protect against the daily wear and tear the product will have to undergo.	✔	All surfaces are either waterproof or finished. After a few weeks of testing the product has shown little signs of wear and tear after a quick wipe down with a bit of water and a bit of kitchen towel.

Manufacturing Specification

Specification	Achieved?	Analysis
Use PLA, ABS or Aluminium for Brackets	✔	PLA used for Brackets. After a few weeks of testing showing no signs of real wear.
Use HDF or Hardwood for Base	✔	HDF used for Base. So far no problems, the material is adequately waterproof for the requirements.
Use Acrylic for Pot Holder and Base Protector	✔	Acrylic is highly durable and easy to manufacture with. After multiple spillages of dirt the white acrylic is still showing no signs of wear.
Use CNC Machine or 3D Printer to construct Brackets	✔	I used a 3D printer due to the high cost of a aluminium CNC machine. The 3D printer was very slow but as the product was only a prototype this had no real effect.
Use Laser Cutter/Engraver for Pot Holder	✔	The laser cutter was very quick at cutting the material and always cut within very small tolerances.
Use brushed aluminium rods for support.	✔	I used aluminium rods left over from previous projects. I brushed them down using wire wool to create the shiny effect for the finished product.

Peer and Client Assessment



Peer Assessment

Overview
To evaluate my peers' opinion on my product, I took a survey with 25 people to get a broad range of opinions. It should be noted that I know the most of the people so there may be a slight bias.

Opinion on the Product
The opinions on the product were generally very good. With only one person claiming that there was a major flaw. However this flaw was not really relevant to the design of the product. They said "I don't really see the point of the product if most people have a vegetable patch." I would claim that this product is trying to make the growing of plants easier inside the home.

Rating of the Product
The product was rated highly with no rating below very good which is outstanding. Particular comments were on the finished quality of the product and its aesthetically pleasing look.

Conclusion
Overall my peers' opinion on the product was great. Many said that they would consider buying the product even at the higher price if it integrated the circuit that I had designed as they found the monitoring of the plants features especially interesting.

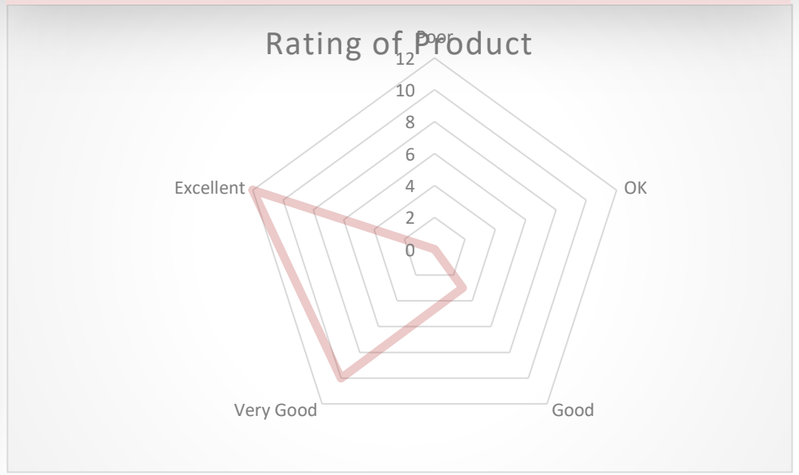
Client Assessment

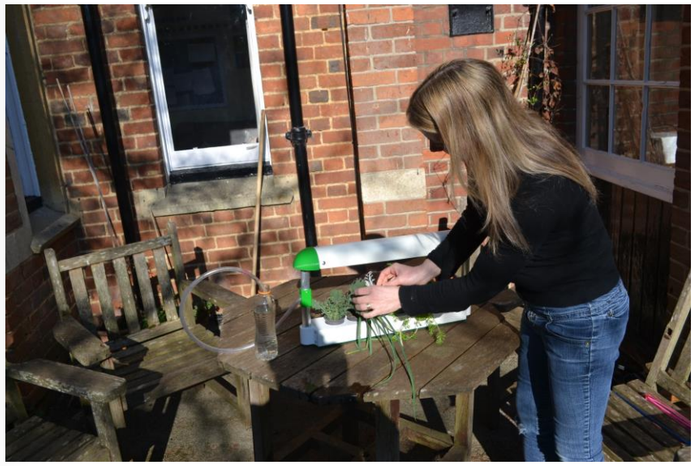
Overview
I took the product to the client's home to show her and get opinions and any necessary feedback.

Opinion at first glance
The opinions at first glance were great with her stating 'It perfectly suits the style of my kitchen'. She liked the aesthetics of the pots as well and found the removing and replacement of pots especially easy.

Opinion after a few weeks of utilization
After a few of the client being able to use the product, I returned to gather her opinion. She was very happy with the product and claimed that because it was in her kitchen space it encouraged her to look after the plants. The addition of a light was also very useful for letting her plants get extra light during the dark winter months.

Conclusion
My client felt the client definitely met the Criteria. She was slightly disappointed to see that the pump mechanism had not been included but understood that with more development this product would be able to house such a feature. She says she now uses the product every day and has had multiple positive comments around it from visitors.





Peer Review and Testing

I chose two of my peers at random to give an in depth review on the product in contrast to the Amazon reviews that I read during my initial product research in section A. Below are the results.

Peer Review Card 1

★ ★ ★ ★ ★

A useful product with very good intentions for bringing healthy wellbeing to all. However I don't think it is for everyone. I imagine that after a while the maintenance of the product would become tedious. I really liked the colours of the product and think that it would be awesome if in the real product I was able to customize the pallet of the product when ordering so I could make it suit my taste. I think Freddie's care during manufacture has really shown as there appears to be absolutely no defect that I could find on the product. If I were to change anything, I would maybe think about using a different base material as I am not sure the foam would last after a few months of use.

Response to Review

I agree with most of my peer's points and take on board the fact HDF may not be the best material choice for this product in the long term. However for a prototype it is fine for its purpose. In manufacturing perhaps it could be lined with a waterproof rubber material.

Peer Review Card 2

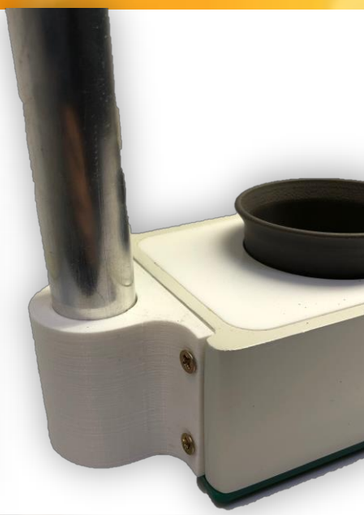
★ ★ ★ ½

With use of the product, I wonder if PLA was the best material choice for working with organic matter considering that it is biodegradable. A much better alternative in my opinion would be ABS. Although it looks aesthetically pleasing and functional . Also I do not think the lighting will be as effective as sunlight. I thought the cable organiser was a good idea but was little ugly and there should be more pots.

Response to Review

As seen before in my folder, I did consider the possibility of using ABS instead of PLA but found it to be easier to use PLA for prototyping. I take on board the comments about the cable organiser and will try and correct in modifications.

Testing



Waterproof ability

To test the waterproof ability of the product. I left it out in the elements where there were several instances of rain and took it in to analyze the results. A photo of the product is pictured to the right after the testing. As you can see from the photo, there is no real sign of damage from the water and this is shown throughout the entirety of the product. This shows that the product is highly water resistant externally.

UV Protection

I wanted to see if prolonged sunlight would have any effect on the products white colour as I have noticed that many of my white plastic products have over the years discoloured due the UV light emitted by the sun. I left the product for 8 hours in the sunlight. However this test is slightly flawed as the effects of UV light would take much longer than the period the product was left for and also the UV light was not great as this was taken in winter. In conclusion, I do not definitely know if my product is resistant to UV light so I will just have to rely on the label on the spray-paint and the filament to be true in that it will keep its colour.

Prolonged Usage Test

I left the LED lights inside the product running for 48 hours to see if there were any problems in terms of thermal stability and power consumption. I came back to find the LEDs warm to the touch but no apparent problems were present apart from some adhesive on the LED strip peeling away due to the heat. This test therefore passed.

Evaluation

Fitness for Purpose

My product was able to fulfill almost all of the points set out in the criteria and in the comparison to specification. Unfortunately the pumping mechanism never made it in to the final product however this system had been fully developed and testing and I am sure with more time I would have been able to get it done. Many of my peers have commented that my product has often caught their attention for it's unique style and characteristics. The use of an LED light to help grow the plants is very useful for its intended purpose and also gives the product a atmospheric glow which makes it stand out amongst other similar products. The use of a cable organiser to conceal the cables in the product gives the product a minimalist look which is what the client was looking for when I set out my design brief.

Manufacture Process and Achievements

At first I struggled with design fixation, which significantly limited my options, however with research from looking through the textbook I found several creative ways of sketching new concepts which could influence my ideas. I feel this was vital for the success of the design of my product as it shows I am able to come up with an idea, evaluate its strengths and weaknesses and then come up with a completely new one. This means all my ideas were highly evaluated and researched to ensure my products design was the best it could be.

I developed my modeling skills as well, which before I did not have much experience with as normally in our studies we would simply construct what we first came up with. Now I realize the importance of modeling with materials and digitally for ensuring my design ideas are the best they can be. Modelling was also crucial for working out how I could construct my final product through different techniques. For example, I thought of the roof being made out of wood veneer at first however I realized this would be technically quite challenging and a PVC tube as used in the final design would be just as good and much easier. My CAD skills were already good at the beginning of the project but I had never really used them in practice to construct a full product. The use of several different components helped me broaden my knowledge in Autodesk fusion. Presenting my ideas in this folder has also meant I have learnt new features around Fusion 360 which I might not have come across if I was only working on the designs. I have now realised presenting my ideas well is incredibly important to be a good designer.

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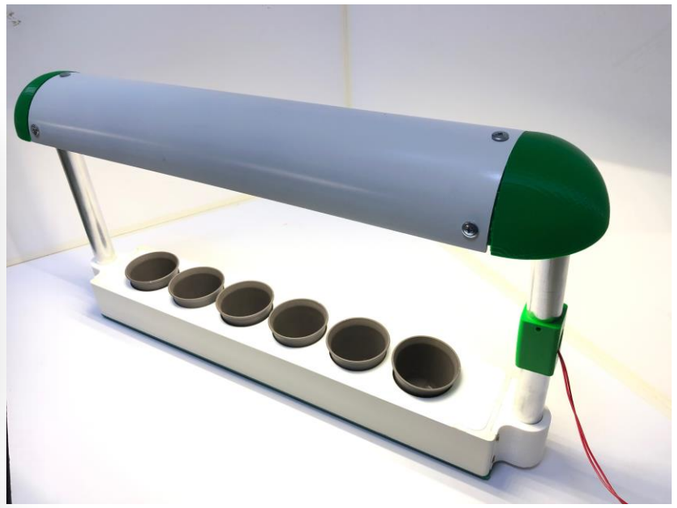
The manufacturing process was fairly smooth as I had planned out everything in advance so I was never really under pressure to get the product completed. However I did have to make sure I had a balance between my written work and practical.

Product Testing

All the tests I tried on the previous page passed proving that my product is reliable and meets the specification I set out. I also gathered peer and client assessment material which I could use to count towards the testing of my product and receive feedback on potential modifications that could be implemented.

Conclusion

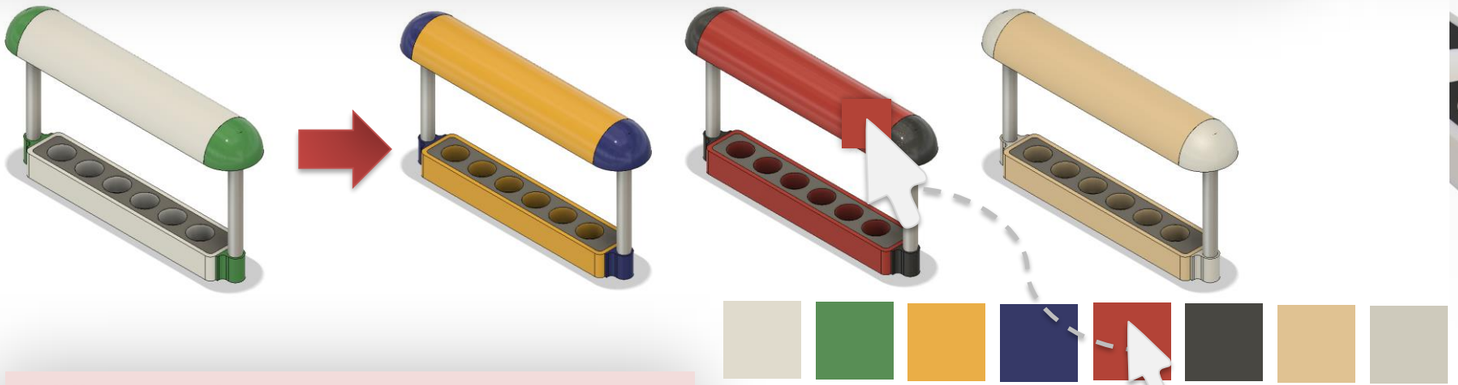
Overall, I am very pleased with how my product turned out. I truly believe the product is of a high quality and goes beyond the prototype that is required (I could imagine my product being on sale in a high street store). In the future when working on projects I will remember the effective use of my planning and how important it is towards working towards a deadline.



Possible Modifications

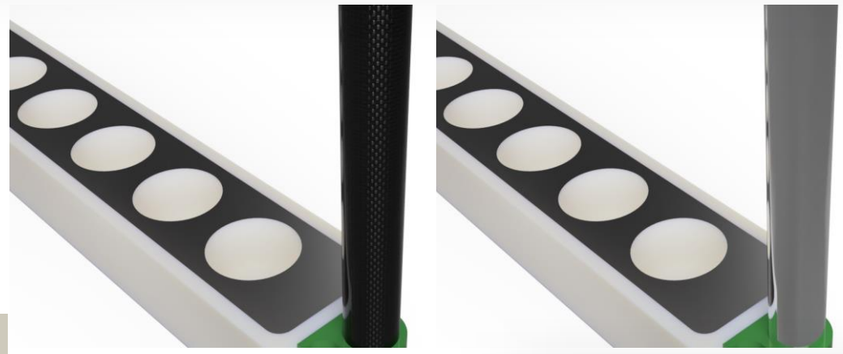
Colour and Appearance Customizability

Nowadays, consumers are expecting more customizability when they buy their product. Buyers like the idea that the product is especially unique to them and its appearance is “chosen” by the customer. This also means a product can be customized to fit a wide variety of environments. Pictured below is a mock up of the product order page where the user could drag in a colour onto either the bracket or the roof/base unit to style the product according to how they want it. This would increase the value of the product as customizability is often seen as a premium feature.



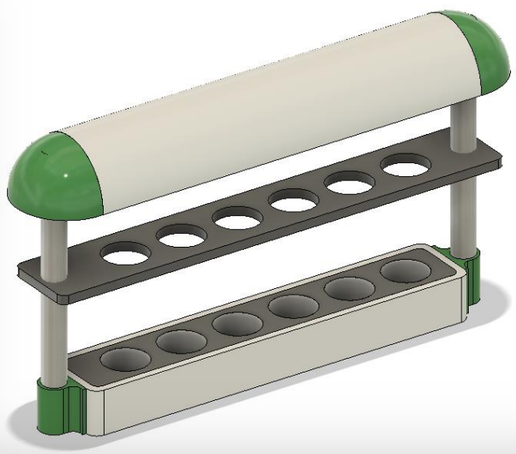
Modifying materials

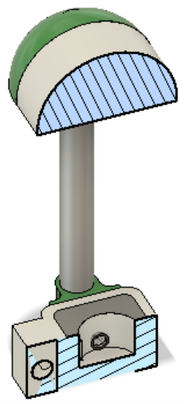
I felt like more could have been done with the aluminum rods. I felt like black would have been a nice tone against the white and green as it would continue the monochromatic theme. Immediately when I saw the aluminum rods they reminded me of a racing baton like the one pictured below, batons like this are often powder coated to give a different colour. For my product I could have used powder coating for the rods but unfortunately our school does not have the facilities to do this.

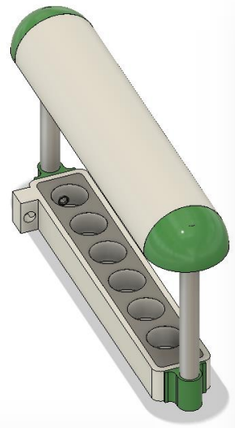


Adding more layers

One of my peers commented that it would be good if there was room for more pots. I did feel that there was already enough room for plenty of pots but I came up with the concept of an “add on” which the consumer could buy separately to expand their pot count. Another add on I considered was a pipe expander bracket which would perform a similar function to my cable organizer but it would allow the consumer to repeat layers allowing them to house more and more layers. However this would bring stability issues which would require it to be mounted.







Moving position of cable organiser

The cable organiser was commented on as being “ugly” by one of my peers. To resolve this issue of it being obtrusive, I considered the idea of moving it towards the bottom of the product behind the front in order that the wires and tubing could be easily be fed hidden away from view. I agree that this design was probably better than having a cable organizer in the middle of the product. Another benefit of this design is that the product would be more durable as the cables would not be hanging loose prone to being tugged.

Conclusion

These ideas are just a selection of the wide variety of improvements I could have made to my product to make the product more accessible, user friendly and aesthetically pleasing. This is why most product designers use iterative design to prototype, test and analyse. This process for many companies usually happens over many years with thousands of people providing feedback. However for my NEA, this would not be possible due to time constraints and manufacturing costs but it is an important fact to consider.

End of File